OIL SHALE TRACT C-b

DETAILED DEVELOPMENT PLAN AND RELATED MATERIALS

VOLUME 1 OF 2

- INTRODUCTION
- DETAILED DEVELOPMENT PLAN
- ENVIRONMENTAL CONTROL PLANS
- ENVIRONMENTAL MONITORING PROGRAM

C-b SHALE OIL PROJECT

ASHLAND OIL, INC.
SHELL OIL CO., OPERATOR

Oil Shale Tract C-b

DETAILED DEVELOPMENT PLAN
AND
RELATED MATERIALS

VOLUME I

PREPARED FOR SUBMITTAL TO THE AREA OIL SHALE SUPERVISOR PURSUANT TO LEASE C-20341 ISSUED UNDER THE FEDERAL PROTOTYPE OIL SHALE LEASING PROGRAM

FEBRUARY 1976

C-b SHALE OIL PROJECT
ASHLAND OIL, INC.
SHELL OIL CO., OPERATOR

VOLUME I DETAILED DEVELOPMENT PLAN

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I. GENERAL INTRODUCTION AND SUMMARY

A. Introduction

The C-b Shale Oil Project is a joint venture of Ashland Oil, Inc. and Shell Oil Company. Shell Oil Company (Operator) is operator of the joint venture (Lessee). The joint venture was organized to acquire the Federal Oil Shale Lease Tract C-b (the Tract or Tract C-b), under Lease C20341 from the United States, and to develop the reserve subject to the Lease. The Lease was acquired effective April 1, 1974 for a competitive bonus bid of $117,788,000.36, payable in five annual installments. By November 1975, the Lessee had paid the first two installments of $23,557,600.08 each, on April 1, 1974, and April 1, 1975. The Lease grants the exclusive right to mine and process oil shale from the approximately 5094 acres contained in the Tract.

This Detailed Development Plan and Related Materials (DDP) is being submitted to the Area Oil Shale Supervisor (AOSS) by the Lessee, as required by Section 10 of the Lease, and in compliance with all terms and provisions referenced therein. The submittal is composed of two volumes:

<u>Volume I</u> - Detailed Development Plan

Section I: General Introduction and Summary

Section II: Phase I - Mine Development

Section III: Phase II - Plant Construction

Section IV: Phase III - Plant Operations
Phase IV - Post-operations

Section V: Control Plans

Section VI: Monitoring Programs

<u>Volume II</u> - Summary of First-year Environmental Baseline Programs and Environmental Setting

Section VII: Introduction and Summary

Section VIII: Geology and Resources

Section IX: Hydrology and Water Quality

Section X: Climate and Air Quality

Section XI: Biotic Communities

Section XII: Soil Survey and Productivity Assessment

Section XIII: Scenic and Archaeological Values

Section XIV: Off-tract Corridors

The Lease requires that certain data and information be submitted to the AOSS prior to approval of the DDP. The Lessee has previously submitted to the AOSS five quarterly baseline data reports (Quarterly Data Reports) and five quarterly summary reports (Summary Reports) for the yearly quarters ending November 1974 and February, May, August and November 1975. This DDP, which is based in part upon the above described reports, meets or exceeds all requirements of the Lease for material to be submitted prior to development operations on the Tract. The DDP provides a comprehensive statement of the Lessee's plan for proposed operations on the Tract, including schedules, plans and procedures by the Lessee to meet the environmental criteria and protection requirements.

In keeping with the objectives of the leasing program, and to meet the due diligence requirements of the Lease, the Lessee respectfully requests the AOSS to review and approve the DDP at the earliest possible date. Such approval is required to permit the Lessee to commence the programs necessary for Tract development and to offset the bonus payments as provided for in the Lease.

B. Summary of Federal Prototype Oil Shale Leasing Program

During the 50 years following the inclusion of oil shale in the Federal Mineral Leasing Act of 1920, no federal oil shale lands were leased to the public. In early 1971, the states of Colorado, Wyoming and Utah submitted reports to the Secretary of the Interior on expected economic and environmental effects of the development of oil shale in those states. Later the same year, the Secretary of the Interior announced plans for a proposed Federal Prototype Oil Shale Leasing Program. From mid-1971 through 1973, a number of activities preliminary to a decision to proceed with the proposed program took place. Those activities included: an exploratory core drilling program; nomination of proposed lease tracts by the public; establishment of a federal oil shale task force comprised of representatives from federal, state and local governments; and the preparation and publication of a draft and final environmental impact statement by the Department of the Interior in accordance with the provisions of the National Environmental Policy Act. Following the publication of the final environmental statement for the Prototype Oil Shale Leasing Program in August 1973, the Department of the Interior published its intent to offer for lease two oil shale tracts in each of the states of Colorado, Utah and Wyoming. Each tract comprised no more than 5120 acres.

As stated in the final environmental statement, the goal of the leasing program was to:

> "... provide a new source of energy for the nation by stimulating the timely development of commercial oil shale technology by private enterprise, and to do so in a manner that will assure the minimum possible impact on the present environment while providing for future restoration of the immediate and surrounding area."

The Leasing Program also established the following objectives:

- provide a new source of energy that will increase the range of energy options available to the nation by stimulating the timely development of commercial oil shale technology by private industry;

- insure the environmental integrity of the affected areas, and concurrently define, describe, and develop a full range of environmental safeguards and restoration techniques that can be reasonably incorporated into the planning for a possible mature oil shale industry in the future;

- permit an equitable return to all parties in the development of this public resource; and

- develop management expertise in the leasing and supervision of oil shale resource development in order to provide the basis for future administrative procedures.

Commencing with competitive bid sales in January 1974, the Department of the Interior offered for lease the six selected tracts in Colorado, Utah and Wyoming, and during the following six months leased four of these tracts, two each in Colorado and Utah. Neither of the two Wyoming tracts received acceptable bids.

The Federal Prototype Oil Shale Leasing Program is administered by the Area Oil Shale Supervisor (AOSS) of the Conservation Division, U. S. Geological Survey, Department of the Interior. The AOSS has the ultimate authority for the approval of development plans. However, he receives advice from other interested governmental agencies and the Oil Shale Environmental Advisory Panel (OSEAP). The AOSS submits all significant proposals, including Exploration and Development Plans, to the OSEAP for comment on environmental aspects on a timely basis. The AOSS is required by the Lease provisions to react to the Lessee's approval requests without undue delay.

Numerous specific environmental controls are included in the Lease and the Environmental Stipulations (Stipulations). These include the following provisions:

- "The Lessee shall conduct all operations ... in compliance with all applicable federal, state, and local water pollution control, water quality, air pollution control, air quality, noise control, and land reclamation statutes, regulations and standards."

- "The Lessee shall avoid, or, where avoidance is impracticable, minimize and, where practicable, repair damage to the environment, including the land, the water and air."

- A two-year baseline data collection program must be conducted under the Lease; data to be collected are to cover the areas of surface water, ground water, air quality, soils, flora and fauna.

- Environmental monitoring must be conducted before, during, and subsequent to development operations, in order to provide: 1) a record of changes from conditions existing prior to development operations as established by the collection of baseline data; 2) a continuing check on compliance with the provisions of the Lease (including the Stipulations) and all applicable federal, state and local environmental protection and pollution control requirements; 3) timely notice of detrimental effects and conditions requiring correction; and 4) a factual basis for revision or amendment of the Stipulations.

- The Lessee is required to submit, for approval by the AOSS, a Fish and Wildlife Management Plan for the Tract. The plan is to include the steps which the Lessee shall take to: "1) avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for the enjoyment of the wildlife resources on such lands as may be mutually agreed upon."

- "The Lessee shall ... conduct a thorough and professional investigation of any portion of the leased lands to be used, including, but not limited to, those areas to be used for mining, processing, or disposal operations or roads, for objects of historic or scientific interest ..."

- The Stipulations call for Lessee to control erosion, and to rehabilitate and revegetate disturbed lands. An initial Management Plan for achieving this objective is required to be submitted not less than 60 days prior to the start of mining and site preparation and is to be updated each year thereafter.

- the Stipulations specify scenic standards to be followed " ... in all designing, clearing, earthmoving and construction activities." The Lease further requires that aesthetic values be considered " ... in all planning, construction, reclamation and mining operations." In addition, all operations are to be performed so as "to minimize visual impact, make use of the natural topography, and to achieve harmony with the landscape."

The Lessee submitted, in April and May 1974, a Preliminary Development Plan and an Exploration Plan describing the exploration and environmental baseline programs proposed to be carried out on the Tract. Those plans were subsequently approved by the AOSS and the collection of environmental baseline data began in early summer 1974, with the commencement of some programs delayed until fall. The first-year program is now completed. As required by the Lease, the studies will continue through the second year. The Quarterly Data Reports are available for inspection by the public at the AOSS' office in Grand Junction, Colorado.

C. Organization and Use of the Detailed Development Plan and Related Materials

The DDP must necessarily be both extensive and flexible. As a multi-purpose document, there is no single means of organization which can make it completely effective for every purpose. The final format selected represents an attempt to present information in a direct, specific, understandable and practical manner. This format is designed to meet all of the requirements of the Lease, to be usable as a means of administering the Lease requirements and, at the same time to be understandable by the public. The format used here is believed to be the most adaptable for all purposes. The organization, rationale and objectives followed in the preparation of the DDP are explained below.

As a general guide, Volume I contains all proposed actions, plans and schedules describing Tract development. Volume II contains a summary of the first-year environmental baseline programs and a description of the existing environmental setting. The first section of each volume is a summary of that volume and is followed by more detailed descriptions in the remaining sections. Descriptions of proposed activity described in Volume I are broken into four chronological time phases: Phase I describes all actions to be taken prior to beginning construction of the commercial plant facility; Phase II is the plant and mine construction phase; Phase III is the operational phase of the commercial mine and plant; and Phase IV is the post-operations phase.

The proposed actions described in Volume I include alternatives when appropriate. Similarly, major environmental control facilities such as dams and water treatment facilities, are described as proposed actions. Conversely, environmental control methods and procedures are included in the environmental control plans section (Section V). Environmental control plans include a summary of potential impacts which the Lessee intends to avoid or mitigate as well as a description of the procedures and methods to be followed. These plans generally describe procedures which are applicable to a variety of different activities (e.g., erosion control procedures which apply to roads, plant construction, dams, etc.). By concentrating all planning in Section V, the format avoids the need for constant repetition throughout the action section.

A distinction has been made between baseline programs and monitoring programs. The baseline programs are approved by the AOSS and are currently in their second year of operation. These programs provide the basis for the first-year summary as described in Volume II. The monitoring programs will follow the baseline programs and are designed to measure changes from the baseline. Because the monitoring programs require approval of the AOSS, they have been included in Volume I as part of the development program.

The following material describes the specific content of each section of the DDP.

Section I, including this part, contains introductory material relating to the Tract, summarizes the Federal Prototype Oil Shale Leasing Program, describes the organization and content of the Detailed Development Plan and Related Materials and provides an executive summary of Volume I.

Section II contains the plans, schedules and descriptions of proposed future operations on the Tract during Phase I - Mine Development. Phase I will commence with approval of the DDP and end with the start of commercial plant construction and will encompass a period of approximately five years. A description and schedule of planned activities, discussion of alternatives to planned activities, description of control plans for environmental protection and estimates of manpower requirements are included.

Section III contains the plans, schedules and descriptions of proposed operations on the Tract during Phase II - Plant Construction. Phase II begins with commercial plant construction and ends with commencement of commercial plant operations. This phase is expected to last approximately four years. A description and schedule of planned activities, discussion of alternatives to planned activities, description of control measures and procedures to be taken for environmental protection and estimates of manpower requirements are included.

Section IV contains the plans, schedules and descriptions of proposed future operations on the Tract during Phase III - Plant Operations, and during Phase IV - Post-operations. Phase III begins with commercial plant start-up and is expected to continue for an approximate 20-year operating life. Phase IV will begin after termination of plant operations. Descriptions and schedules of planned activities, environmental control measures and manpower requirements are included.

Section V contains a compilation of the specific environmental control plans developed by the Lessee for compliance with the Lease requirements during all phases. These plans include control procedures and criteria for air, water and noise pollution; protection of historic, scientific and aesthetic values; fire prevention and control; health and safety; overburden management; processed shale disposal and disposal of other wastes. In addition, separate plans required by the Stipulations for fish and wildlife management, erosion control, surface rehabilitation, oil and hazardous materials spill contingencies and off-tract corridors are included.

Section VI contains a description of monitoring programs that will be conducted to measure the impact of activity on the Tract against baseline data.

Section VII introduces and provides an overview of Volume II. Volume II contains a summary of the first-year baseline programs and the environmental setting of the Tract, as well as the environmental setting for off-tract corridors. The remaining sections of Volume II (Sections VIII through XIV) describe geology and resources, water, air, biotic communities, soils, scenic and archaeological values and off-tract corridors related to the Tract. Each section is organized to describe the nature, scope and extent of the baseline programs; provide summaries of the pertinent data collected in those programs; evaluate trends and interrelationships; and analyze the data obtained from the investigations.

The planning, construction and operation of a commercial shale oil project is a large and complex endeavor involving thousands of people and consideration of many factors. Many activities and events cannot be started until others have been completed and evaluated. During the course of any projected commercial development program, some changes and modifications will inevitably be necessary. The commercialization process is dynamic and must retain flexibility to permit reaction to ever-changing conditions. This document describes Lessee's plans for the path of development now considered most likely, together with the various alternatives which now can be recognized. Where alternatives are recognized, the varying impacts from one choice or another are discussed and any significant changes that would occur from alternative choices are considered. In general, it is not expected that changes in detail will have any major effect on the environmental impact of the project. Any significant changes would be reviewed with the AOSS and appropriate approvals obtained.

D. Summary of Lessee's Proposed Programs

This part is designed to provide an executive summary of Volume I, which contains the plans, schedules and descriptions of mine development, plant construction, operations and post-operations activities which the Lessee proposes to carry out on the Tract. These activities are set forth in detail in the remaining sections of Volume I. In addition, this summary describes plans for various related off-tract activities which are not directly under the control of the AOSS, but which are described for purposes of continuity. The environmental control plans and procedures which will be employed to mitigate environmental change, and the environmental monitoring programs which will be employed by the Lessee during all phases of activity to measure changes in the baseline environment, are also summarized. Cost estimates for capital and operating expenditures are included.

Under the Lessee's plan presented in this DDP, the proposed activities will proceed under a general plan comprised of numerous steps. Of necessity, planning and design in a project of this magnitude must remain a flexible process with many significant decision points along the path. Time phases (Phases I, II, III and IV) have been used in the DDP for convenience of discussion. A major interim decision point will occur at the conclusion of Phase I on whether to proceed with construction of the commercial plant. The information and experience gained in Phase I will be reviewed, together with economic and political considerations which must then be favorable, before Lessee can make a final decision to proceed into Phase II. Commitment of the major portion of expenditures in what approximates a billon-dollar project would not be made until such work is completed.

However, based upon present knowledge and information, Lessee has prepared this plan describing the most probable path of development. Variations from the plan will most likely occur in matters of degree and detail. When reasonable alternatives for significant actions exist, they are discussed and the presently preferred alternative is noted in the detailed sections describing the project.

1. Description and Location of the Tract

The DDP relates to the development of Tract C-b of the Federal Prototype Oil Shale Leasing Program consisting of 5,093.9 acres, more or less, which is shown in Figure I-1 and is located in Rio Blanco County, Colorado as follows:

T. 3 S., R. 96 W., 6th P. M.

Sec. 5, W½ SE¼, SW¼; Sec. 6, lots 6 and 7, E½ SW¼, SE¼; Sec. 7, lots 1, 2, 3, 4, E½ W½, E½; Sec. 8, W½ NE¼, NW¼, S½; Sec. 9, SW¼; Sec. 16, NW¼, W½ SW¼; Sec. 17; Sec. 18, lots 1, 2, 3, 4, E½ W½, E½.

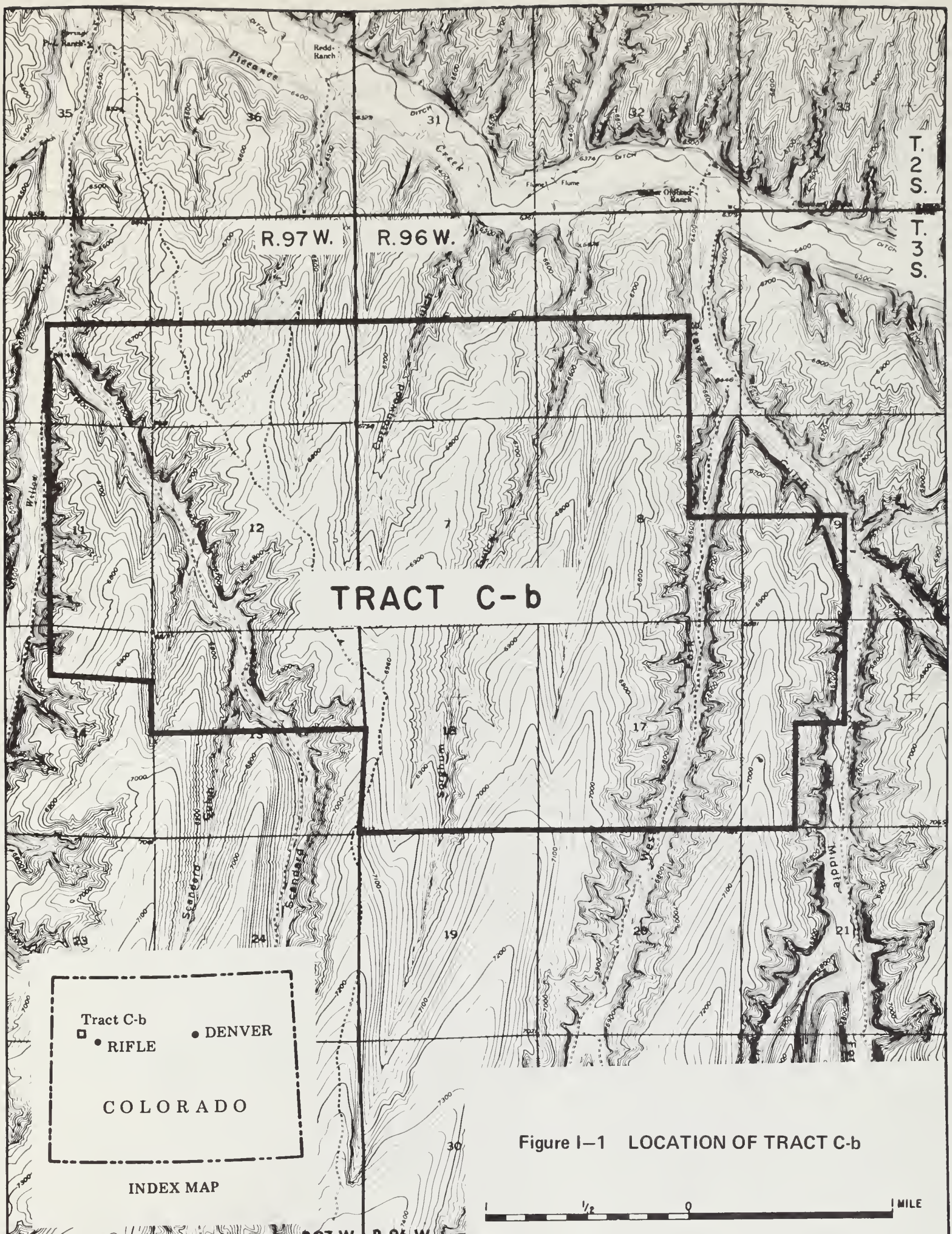


Figure I–1 LOCATION OF TRACT C-b

T. 3 S., R. 97 W., 6th P. M.

Sec. 1, S½; Sec. 2, SE¼; Sec. 11, E½; Sec. 12; Sec. 13, N½; Sec. 14, N½ NE¼.

The Tract is located in a sparsely populated region of Rio Blanco County in the Piceance Creek basin in northwestern Colorado. Terrain on the Tract consists primarily of undulating valleys and ridges trending in a northeasterly direction and draining into Piceance Creek. The northern edge of the Tract is approximately one-half mile south of Piceance Creek at the confluence with Stewart Gulch. Piceance Creek then flows northwesterly approximately 24 miles to its confluence with the White River. There are a few scattered ranches along Piceance Creek. The towns nearest to the Tract are Meeker (40 miles), Rifle (40 miles) and Rangely (65 miles).

Elevations on the Tract vary from 6400 feet in the lowest valley bottoms to 7100 feet on the ridges at the southern edge of the Tract. The climate is semiarid with snow cover occurring variably from October to May. The climate supports sparse vegetation, with sagebrush and pinyon-juniper communities being dominant. Approximately 45% of the Tract (primarily the flat ridgetops) was chained by the federal government in 1967. Chaining is a technique designed to improve range production by removing sage and pinyon-juniper. Historically, the Tract has been used primarily for cattle grazing and providing winter range for mule deer.

Figures I-2, I-3, I-4 and I-5 show several representative views of various areas of the Tract. A detailed description of the environmental setting of the Tract is contained in Volume II.

2. Schedule, Manpower and Cost Estimates

a. Schedule

Development, construction, operation and eventual decommissioning of the proposed commercial shale oil complex will proceed on the four-phase schedule as set forth in Figure I-6. Major facilities associated with the project include: shafts and mine; conveyors; crushers; coarse-ore stockpile; roads; power facilities; communications facilities; pipelines; dams; water containment and storage systems; retorting and upgrading process facilities; processed shale disposal pile; tankage; and various off-tract support facilities.

Phase I programs will commence following approval of the DDP by the AOSS. The location, size and timing of all activities described above are illustrated by phase in the project plot plan shown in Figure I-7.

Phase I activity includes: final engineering design, contractor selection and procurement, preparing a mine site; sinking and equipping two approximately 30-foot diameter vertical shafts; installing

Figure I–2 VIEW OF TRACT LOOKING SOUTH ACROSS PICEANCE CREEK

Figure I–3 VIEW LOOKING NORTHEAST ACROSS SORGHUM GULCH

Figure I–4 TYPICAL CHAINED AREA BETWEEN COTTONWOOD GULCH AND SUPPORT FACILITY

Figure 1–5 VIEW LOOKING NORTH DOWN COTTONWOOD GULCH

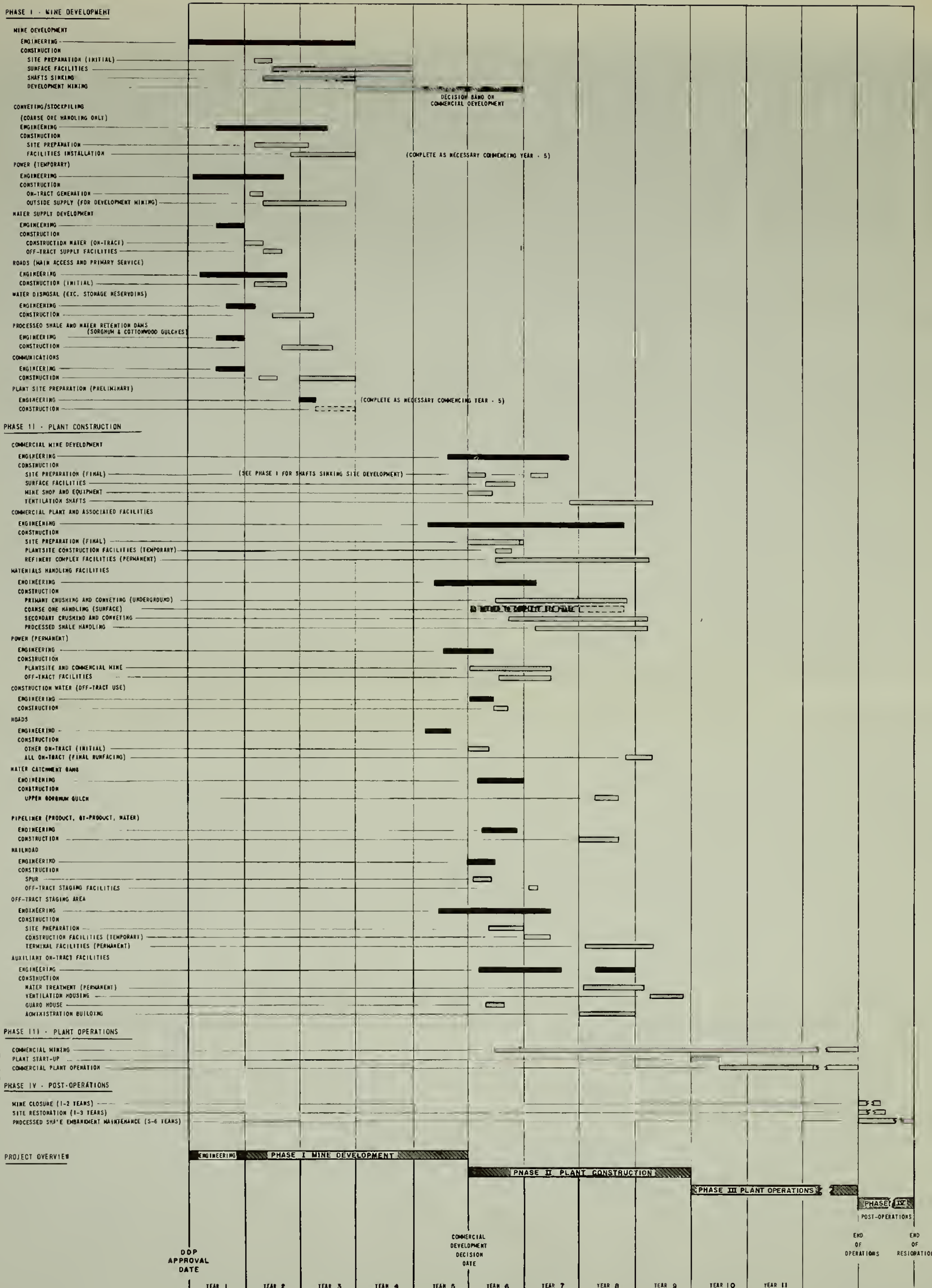


Figure I—6 PROPOSED DEVELOPMENT SCHEDULES
C-b SHALE OIL PROJECT

Figure I–7 PROJECT PLOT PLAN, PHASES I, II, AND III

underground crushing equipment and surface conveyors; building mine surface facilities; constructing on-tract service roads and an all-weather access road between the Tract and the existing Piceance Creek road; preparing a coarse ore stockpile area near the head of Cottonwood Gulch; constructing a water catchment dam in Sorghum Gulch; and constructing a runoff control dam below the coarse-ore stockpile in Cottonwood Gulch. Interim water and power facilities will be installed and a water treatment facility will also be constructed. Phase I is scheduled to take approximately five years to complete.

The chief reason for the development mining program is to resolve technical uncertainties with respect to rock mechanics and their effect on attainable extraction ratios. Information obtained during the exploration phase has indicated the rock to be weaker than expected and that extraction ratios may have to be lower than presumed at the time of submitting the bid for the Tract. Throughout the development mining program, the project staff will evaluate the results of the mining operations in order to select the commerical mining interval and select and optimize the room-and-pillar design. This information will be included in a continuing, comprehensive study of the project to assess project economics. The merit of continuing the project at the end of the mine development program will depend on the existence of favorable economic, technical, political and environmental factors which at this time are unknown. These important factors include: construction cost escalation; the projected market value of oil and by-products; the cost and availability of capital; and government policy relating to new energy projects.

Assuming favorable projections, Phase II construction of the commercial plant will begin after completion of Phase I. Construction will take about four years. Phase II activities will include construction of: retorting and upgrading facilities; enlarged coarse ore stockpile; surface and underground mine support facilities; primary and secondary ore crushing, handling and storage facilities; processed shale handling facilities; and a possible water storage reservoir in Scandard Gulch. Also during this period all associated off-tract facilities, including a staging area, water diversion and transport facilities, pipelines and terminals, will be completed.

Detailed scheduling, planning and construction will be done for the C-b Shale Oil Project by engineering contractors subject to the Lessee's direction and approval. During all phases of construction, the Lessee will maintain a supervisory staff to monitor construction activities and enforce compliance with the environmental safeguards set forth in Section V.

Continued research and development on methods of oil shale extraction could make it desirable to alter the above schedule. Laboratory studies now underway have shown some promise toward achieving a significantly higher efficiency of recovery than can be reached by present-day retorting methods. If these studies continue to show the same degree of promise in larger-scale experiments, it could become desirable to postpone plant construction until the technology is fully developed. This would allow for maximum conservation of the oil shale resource. If this path is chosen, a modular approach proceeding through pilot plant and semi-commercial or demonstration-size modules may be proposed.

Phase III commercial operation of the shale oil complex is scheduled to commence in the 9th year after DDP approval and will continue for approximately 20 years or until such time as all economically recoverable oil shale beneath the Tract has been processed.

The Phase IV period of post-operations activity will commence following completion of commercial operations. During Phase IV, steps will be taken to decommission the project in an environmentally acceptable manner. This phase will include closing the mine and restoring surface sites utilized for the mine, raw-shale storage, conveyors, the retort and upgrading facilities, roads, dams, corridors, staging areas and other miscellaneous facilities.

b. Manpower

Manpower estimates for the various proposed operations on the Tract for Phases I, II and III are shown in Figure I-8. It must be recognized that actual manpower requirements may vary from these estimates since they will be affected by final timing, engineering design, contractor methods, equipment scheduling and a variety of factors not now determinable. However, the estimates provided are based upon considerable information and planning work done by the Lessee and provide reasonable approximations.

Phase I - Mine Development. Construction manpower is estimated to peak at approximately 425 workers within the first year of construction. Following completion of shaft sinking, mine development work will begin and will continue for approximately two to three years. During this period, the on-tract manpower total will probably drop to approximately 60 people.

Phase II - Plant Construction. Manpower requirements will grow steadily during Phase II to a peak of approximately 3300 workers during the third year of Phase II.

Phase III - Plant and Mine Operations. Once commercial operations commence, it is expected that on-tract operating manpower will be relatively constant at 1000 to 1200 workers.

c. Cost Estimates

Construction and operation of a commercial shale oil project can occur only after further experience is gained and more information is gathered on site characteristics, and detailed engineering design and cost estimates have been prepared. Thus, it must be recognized that

Figure I–8 PROJECT MANPOWER ESTIMATE

any estimates given at this point must of necessity be based upon final design configuration and project scheduling assumptions. However, order-of-magnitude estimates have been made to provide a general projection of the capital and operating costs which are expected to occur in connection with the project. These estimates assume favorable economic and political climates which will allow proceeding on the planned schedules. It is also emphasized that these projections should not be taken as commitments to expend funds. Individual components of costs may vary significantly or be eliminated in actual practice. The project cost estimates are discussed below.

Project Expenditures. Capital cost estimates prepared for this document show overall project costs through the time of plant construction, but exclude interest during construction and deferred capital expenditures. Project estimates do not reflect timing of expenditures and do not include escalation costs. However, under the terms of the Lease, the Lessee expects to commit about $47 million in lease bonus credits prior to the fourth anniversary date (April 1, 1978). As previously mentioned, all expenditures are subject to favorable economic and political conditions. Order-of-magnitude estimates for project expenditures are shown in Table I-1.

3. Mineral Resources

The oil shale resources are located in the Parachute Creek member of the Green River formation beneath the Tract. The oil shale is contained in essentially horizontal sedimentary beds of varying richness. The total thickness of these beds is about 1600 feet. Other minerals such as nahcolite and dawsonite, which occur in abundance in the north-central part of the Piceance Creek basin, do not occur in significant amounts in the zone presently considered for mining.

The project is presently designed to mine selected intervals within the Mahogany zone at an average depth of more than 1200 feet. The mine interval of primary interest at the present time is a section within the Mahogany zone ranging from 74 to 83 feet in thickness across the Tract. This interval has an average richness of about 36 gallons per ton. Within the mine interval of primary interest, several intervals or combinations thereof are being considered as potential mine zones, including: 1) a 45+ foot upper bench averaging 38.7 gallons per ton; 2) a 31+ foot lower bench averaging 32.3 gallons per ton; and 3) the lower 68+ foot zone of the main mine interval, averaging 36.6 gallons per ton. Work to date indicates that the extraction ratios that can be achieved commercially will be materially dependent on the final mining zone selection. A principle purpose of the Phase I program is to obtain data needed to select the preferred mining zone and project commercial mine design.

Table I–1 SUMMARY OF PROJECT EXPENDITURES
FOR A
66,000 TPD SHALE OIL PLANT
LOCATED ON TRACT C-b
(Basis: October, 1975)

CAPITAL COSTS	$Million
PLANT DESIGN AND CONSTRUCTION	
Mining, Crushing and Processed Shale Disposal	100
Pyrolysis Unit	140
Fractionation and Gas Recovery	19
Oil Upgrading, By-Product Recovery & Wast Water Treatment	103
Site Development, Road and Dams	28
Utilities and General Facilities	70
Field Costs	87
Taxes and Insurance	9
Engineering Services and Fees	71
Contingency	58
COMMERCIAL MINE PRE-DEVELOPMENT	9
MINING AND DISPOSAL MOBILE EQUIPMENT	19
CERAMICS, CATALYSTS AND CHEMICALS	12
PREPAID PROCESS LICENSES	6
EMPLOYEE RECRUITMENT AND TRAINING	9
PROJECT MANAGEMENT	17
MISCELLANEOUS OTHER COSTS	17
Subtotal, Capital Costs*	774
OTHER COSTS	
ENVIRONMENTAL PROGRAM AND LEASEHOLD COSTS	26
DEVELOPMENT MINING	15
STARTUP AND FIXIT ALLOWANCE	20
WORKING CAPITAL	15
RESERVES (FIRST THREE LEASE PAYMENTS)	71
Subtotal, Other Costs	147
ESTIMATED TOTAL COSTS (Basis: October, 1975)	921

* Excludes interest during construction and deferred capital investment.

4. Mining, Retorting and Upgrading

Figure I-9 depicts an artist's rendition of a shale oil extraction and refining complex.

The oil shale will be mined by underground room-and-pillar method, which is the only presently demonstrated underground mining technique for oil shale. This mining technology has been extensively investigated in a prototype mining operation conducted by Colony Development Operation on its private lands located near Parachute Creek, about 17 miles north of Grand Valley, Colorado. This mining method has also been investigated by the U. S. Bureau of Mines and others at the Anvil Points Research Station, near Rifle, Colorado.

During Phase I, approximately 3.5 million tons of shale will be mined, crushed and brought to surface for stockpiling. The primary crusher will be located underground near the mine shaft. During Phase III, the commercial mine will produce approximately 66,000 tons per day of raw oil shale over its expected 20-year operating life.

The 66,000 ton-per-day capacity commercial plant will consist of six retort units along with upgrading facilities designed to produce approximately 50,000 barrels per day of shale oil products. In addition, by-products of ammonia (approximately 150 TPD), sulfur (175 TPD) and coke (800 TPD) will also be produced. Alternate upgrading options, such as partial upgrading of crude shale oil, are currently under study.

Present plans are based on the TOSCO II retorting process which mixes crushed, raw shale with heat-carrying solids in a retort drum. Shale is heated to a temperature of about 900°F to produce hydrocarbon vapors. The vapors are recovered for further processing or use, and the remaining solid (processed shale) is removed for disposal. This retorting method has been developed and demonstrated in a 25 TPD pilot plant and in a 1000 TPD semi-works plant. It is possible that, by the time of a go-ahead decision for commercial plant construction, other retorting technology will have advanced to the point that it could be shown to be superior to the TOSCO II process. In this case plans would be modified to incorporate the improved system. Upgrading technology will consist of adaptations of conventional refining processes.

5. Processed-shale Disposal

The solid waste from the retort, referred to as processed shale, is a gray-black granular material resembling silt. As processed shale exits from the retort, it will be cooled and wetted by water sprays in order to control dust and improve compaction characteristics. It then will be transported by conveyor to a surface disposal area located on the Tract in Sorghum Gulch, where it will be deposited in layers and compacted for stability. Compaction also makes it virtually impermeable to water. Approximately 1200 acres will hold all the processed shale

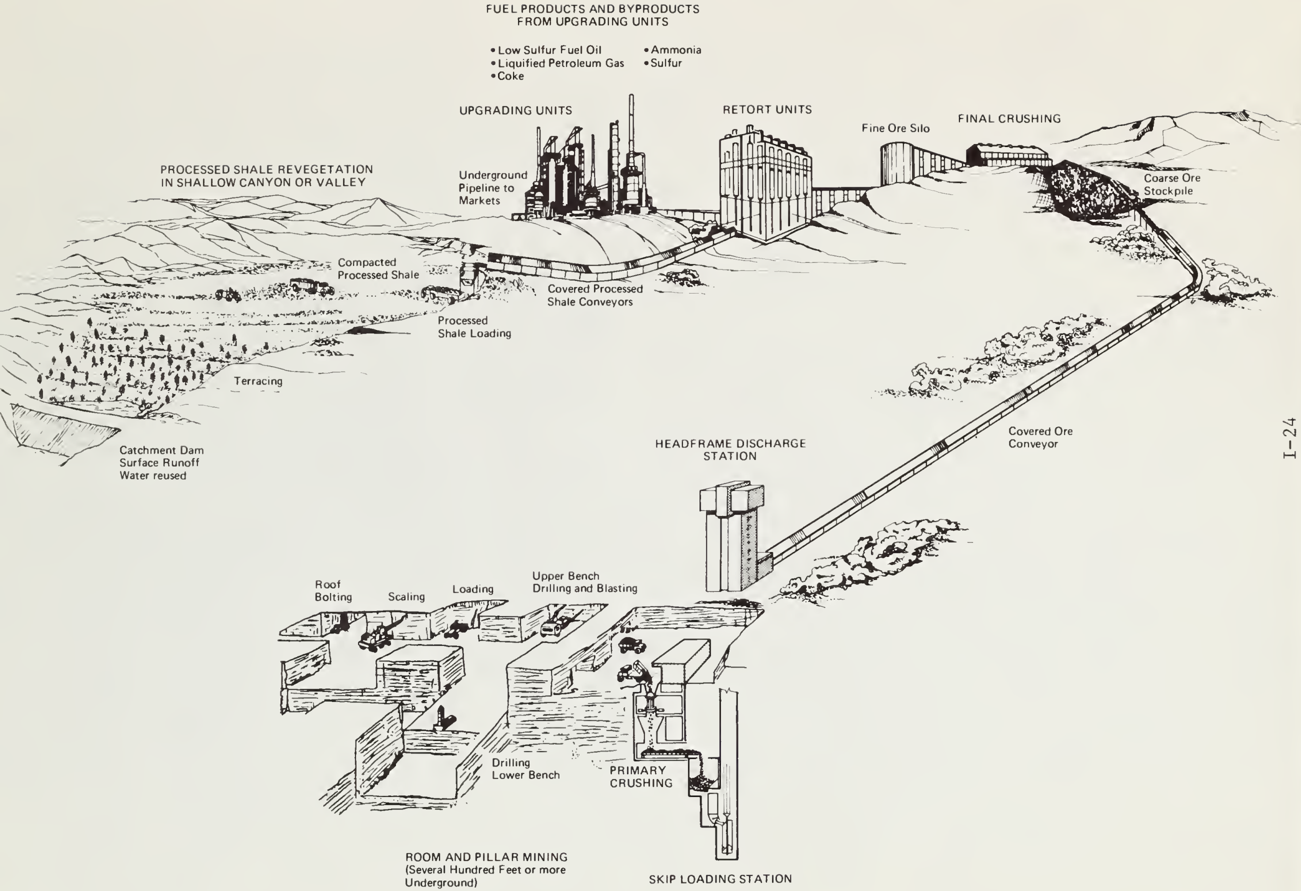


Figure I–9 ARTIST'S RENDITION OF A SHALE OIL COMPLEX

from 20 years of plant operations. When completed, the processed-shale embankment will rise approximately 200 feet above the surrounding terrain.

An alternate plan for use of off-tract portions of Sorghum Gulch south of the Tract has environmental and aesthetic advantages but is not presently planned for use due to uncertainty of federal land administration policy. This alternative will be considered if public policy is changed to clearly authorize such use.

A catchment dam below the processed-shale pile will be constructed across Sorghum Gulch and will provide storage capacity for precipitation run-off from the pile. The run-off will be collected and used in the processing and disposal operations. During Phase I, the Sorghum Gulch dam and reservoir will be utilized to store water encountered in shaft sinking and development mining.

The processed-shale pile will be revegetated in accordance with approved revegetation plans using a variety of plant species. Revegetation of the pile will occur throughout the operational years. However, because much of the surface of the pile is a working surface, most of the revegetation will occur in the later years of plant operation.

6. Water Supply and Disposal

Water supply for project operations will come from a combination of groundwater from mine dewatering, on-tract wells and, if required, surface water pipelined to the Tract. Exploratory work to date indicates that the amount of dewatering required for mine operation will result in insufficient quantities of water for commercial operation. Therefore, some surface water will likely be required. If, as expected, surface water is required to supplement groundwater supply, Lessee expects to pipeline water from the Colorado River, using separately or in combination, direct flow rights and water purchase contracts from existing storage reservoirs. Approximately 12.3 cubic feet per second (CFS) of water will be required for the entire plant complex. To the extent subsurface water quantities exceed expectations, the surface water requirements will be reduced or eliminated. Also, the option exists under the Lease to pump out more underground water than the minimum required to dewater the mine.

Exploratory investigation of the expected quantity of water to be removed from shaft sinking and development mining operations resulted in an estimate that the quantity of water to be removed will peak at 3.7 CFS, with a maximum yearly average of 3.4 CFS. The quality of the water is expected to be suitable for most project uses except for sanitary purposes. If this water source is used for sanitary purposes, it will be treated to drinking water standards.

Underground water recovered in Phase I will likely exceed project needs during that Phase and the excess will be stored, released or reinjected. A plan for flexible response, consistent with regulatory practice, has been developed which includes direct use or release, sprinkler evaporation containment followed by treatment and use or release, reinjection of excess poor-quality water.

7. Off-tract Facilities

In conjunction with construction of the commercial plant, a number of off-tract facilities will be built. A staging area and terminal facility will be built near the railroad in Rifle. A utility corridor will extend south from the Tract to the Colorado River. Pipelines for plant products and by-products will follow utility corridors. The plant product pipeline will follow the utility corridor south to a point of connection with the La Sal pipeline near the Divide road. The by-product and water pipelines will follow the same route and will continue south via Parachute Creek to the Colorado River. Power corridors will extend to the north and east of the Tract. Pipeline corridors for products and by-products will extend from the plant to terminal facilities and common carrier pipelines.

The access-road corridor from the Tract, via the Piceance Creek road to the Rio Blanco Store and then south via State Highway 13/789 to Rifle, will be the principal access corridor for transportation of equipment and materials. Substantial upgrading of existing roads will be required.

8. Plans and Procedures for Environmental Protection

The Lessee has developed a series of plans and procedures for providing environmental protection in connection with activities and operations on the Tract. The specific plans listed below are set forth in Section V:

- Air Pollution Control
- Water Pollution Control
- Noise Pollution Control
- Protection of Objects of Historic or Scientific Interest and Aesthetic Values
- Fire Prevention and Control
- Health and Safety
- Overburden Management
- Processed-shale Disposal
- Disposal Of Other Wastes
- Fish and Wildlife Management Plan
- Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas
- Oil and Hazardous Materials Spill Contingency Plan
- Off-tract Corridors

9. Monitoring Programs

The baseline programs will be continued through the second year, as required by the lease. Thereafter, monitoring programs for measuring changes in baseline conditions will be undertaken. The programs listed below are set forth in detail in Section VI:

- Soil Survey and Productivity Assessment
- Surface Water
- Subsurface Water
- Meteorology and Air Quality
- Biotic Communities
- Noise

10. Due Diligence

Section 10 (a) (3) of the Lease requires that Lessee use due diligence

"... in the orderly development of the Leased Deposits, and ... attain, at as early a time as is consistent with compliance with all the provisions of this lease, production at a rate at least equal to the rate on which minimum royalty is computed under Section 7 (e) (1)."

Lease Section 7 (e) (1) establishes a minimum royalty to be paid by the Lessee commencing in the 6th lease year, due and payable at the end of that year. The minimum royalty is computed on the basis of an annual production rate of 616,000 tons of oil shale containing 30 gallons of shale oil per ton in the 6th year and increasing by a like amount each succeeding year through the 15th lease year.

The proposed development schedule for the Tract is set forth above in Figure I-6 and contains a minimum reasonable time schedule for the commencement of processing of oil shale in a commercial plant on the Tract. The first production following start-up of a commercial plant would commence at the end of the 9th year following DDP approval. Since the commercial plant is designed to process approximately 66,000 tons per day of oil shale, once production has commenced, production royalties will clearly exceed the minimum royalty amounts set forth in the Lease. However, it must be noted that commencement of actual production would not occur on the most optimistic schedule until at least 1985, whereas the minimum royalties due under Section 7 (e) (1) of the Lease commence in 1980.

The time schedule for commercial development of the Lease, as reflected in Figure I-6, is believed to be the most optimistic case for early production of shale oil from the Tract. This schedule is based on the following considerations:

a. Submission and Approval of Exploratory Plans and Baseline Data Programs

The Lease requires at least one full year of baseline data prior to submission of the DDP for the Tract. The Lease was obtained in April 1974 and promptly thereafter on April 10 and May 15, 1974, an Exploration Plan and plans for environmental baseline studies were submitted to the AOSS, respectively. Approval of those programs was authorized by the AOSS between May and September 1974, and the programs commenced shortly after approval.

b. First Year's Baseline Data Program

The collection of one year's baseline data, which is a pre-condition to submission of the DDP, commenced at different times for different programs during 1974, following program approval by the AOSS. The collection of all first-year baseline data was completed prior to November 1, 1975 in order to fully comply with Lease requirements. The DDP has been submitted as soon as possible following complete collection of the first year's annual baseline data.

c. Review and Approval of the DDP

Based upon estimates by the AOSS, it is expected that no more than six months will be required for review, public hearings and approval of the DDP. The Lessee stands ready to assist in any way in expediting the time required for such approval.

d. Mine Development Phase

Following approval of the DDP, Lessee will commence engineering and planning work in order to be able to move promptly into the field and begin mine development activites approximately one year after DDP approval. The sinking of a mine shaft in the Piceance Creek basin will be an unprecedented effort which will provide information for designing and finalizing many plans such as those for mining and water disposal. It is essential to carry out this development work prior to final planning and design for commercial facilities. Following completion of the initial mine development work, the Lessee will: conduct final engineering design work; organize and schedule construction work; select contractors; and obtain permits, rights of way and other authorizations concurrently with development mining. These activities assume that technical, economic, environmental and political conditions are favorable.

e. Construction Time

Construction of the commercial shale oil complex is estimated to take four years. In connection with final design and contracting for the commercial facility, the Lessee will re-evaluate the construction schedule with a view toward expediting construction. However, based upon the substantial prior planning efforts for similar sized facilities, it is believed that little reduction in that time schedule will be obtained due to the complexities of a project of this magnitude.

f. Uncertainties

The foregoing represents the most optimistic schedule for construction of a commercial facility and assumes no unexpected delays during the planning and construction of the plant. It should be noted that in connection with project organization, financing, staffing, manpower, construction materials, rights of way, permits and authorities, the potential for unforeseen delays exists at virtually every step. This means the likelihood of reducing the schedule is rather remote, but the possibility of extending the schedule is relatively large.

Major uncertainties with respect to the mechanical properties of the rock in the C-b mining horizon have made it necessary to incorporate a development mining phase prior to go-ahead planning for a commercial plant. At the time of bidding for the Tract, the rock quality was largely unknown and it was assumed to be similar to that found at the Colony Development Operation mine. However, it has now been found to be of generally poorer quality, resulting in lower permissable extraction ratios and unfavorably affecting the projected economics. In order to assess carefully the achievable recovery, it is now deemed necessary to provide a development mining phase which was not originally planned.

The largest uncertainties and greatest hindrances to planning a schedule are the political questions with respect to present and future government policy on price controls, taxes, etc. Government attitude toward the synthetic fuels industry will determine its ultimate fate.

The Lessee has made all reasonable diligent efforts to attain production at the earliest possible date and will continue to do so on a good-faith basis.

II Phase I - Mine Development

II. Phase I - Mine Development

II. PHASE I - MINE DEVELOPMENT

A. Summary and Schedule of Phase I Activities

Phase I, as used in this DDP, begins with the approval of the DDP by the AOSS and ends at the time a final decision to commence construction of a commercial shale oil plant has been made. This phase is a necessary step in the path to commercial development and is expected to take approximately five years, assuming no delays and favorable economic and political conditions exist.

Following approval of the DDP, Lessee plans first to complete the engineering and design work for the Phase I field program. This includes bid evaluation, contractor selection, and procurement of materials, services and equipment. It is expected that approximately one year will be required for this work, which may be carried out by either the Lessee's or the general contractor's engineering staff or by a combination of the two.

After completion of the engineering and design work, Lessee will prepare a mine surface facility site, sink entry shaft(s) to the proposed mining zone and develop a 40-acre development mine. A containment dam will be constructed in Sorghum Gulch to be used for storage of water produced by shaft sinking and development mining during Phase I. Eventually, the dam in Sorghum Gulch will retain runoff from the processed-shale pile. A new paved access road to the mine site from the Piceance Creek road, as well as other on-site roads, will be constructed. Upon completion of shaft sinking and commencement of development mining, primary crushed shale will be removed from the mine and stockpiled on the surface at a site prepared near the mine surface facilities. A small catchment dam will be constructed in Cottonwood Gulch to retain runoff from the coarse-ore stockpile. Other activities during Phase I will include the construction of: mine support facilities; coarse-ore conveying facilities; water treatment, storage and disposal facilities; communications systems; and interim power systems. In addition, several wells for construction water and a potable water supply will be drilled on the Tract.

In addition to the mine development activities described above, certain other activities which will be required for project completion may or may not be scheduled during Phase I. These activities are those for which the timing can be decided only after further evaluation of development mining, subsurface hydrology, economics and other factors. These activities include construction of a dam and water storage reservoir in Scandard Gulch, site clearance for plant facilities and the commencement of construction of surface water supply systems off-tract.

Phase I activity will result in an estimated peak work force of approximately 425 field personnel toward the end of the second year following DDP approval. The manpower level will decrease to approximately 380 personnel in the third year, and to about 60 personnel in the last two years of Phase I. The following figures and tables summarize the Phase I activities on the Tract:

Phase I Development Schedule and Manpower Estimates. Figure II-1 is the Phase I development schedule showing timing of Phase I activities. The numbers shown on the schedule indicate the range of personnel expected for each activity.

Phase I Project Plot Plan. Figure II-2 shows the Tract areas to be affected by construction activities during Phase I. These plans are considered preliminary to the extent that changes may be required as a result of final engineering and environmental evaluations. However, no major changes are expected.

Phase I Surface Disturbance By Year. Table II-1 lists by year the estimated number of surface acres to be disturbed during Phase I. The vegetation types in the areas to be disturbed are described in Section V. K., Erosion Control and Surface Rehabilitation Plan.

Phase I Manpower Estimate and Skills Breakdown. Figure II-3 shows the on-tract manpower curve and skills breakdown for the Phase I activities. Final manpower figures are dependent on many external factors and subject to changes. Thus, manpower estimates are representative only and should not be taken to represent a precise count at any particular time.

The foregoing material provides a general description of the activity which will occur during Phase I. The work to be done in Phase I is an essential step in the path to construction and operation of the commercial shale oil plant. Operational conditions predicted in Phase I are based on presently-known information derived from the baseline and exploration programs. If actual conditions, in fact, turn out to be significantly different than those predicted, the programs described in the DDP will have to be modified accordingly. In the event any changes are required, they will be made subject to AOSS approval.

The remainder of Section II provides a detailed description of manpower and skills breakdown and project activities.

B. Manpower and Skills

Numerous construction and development mining activities are scheduled to take place during Phase I, extending from the time of approval of the DDP for a period of approximately five years. Figure II-1 shows the range of manpower estimates associated with each of these

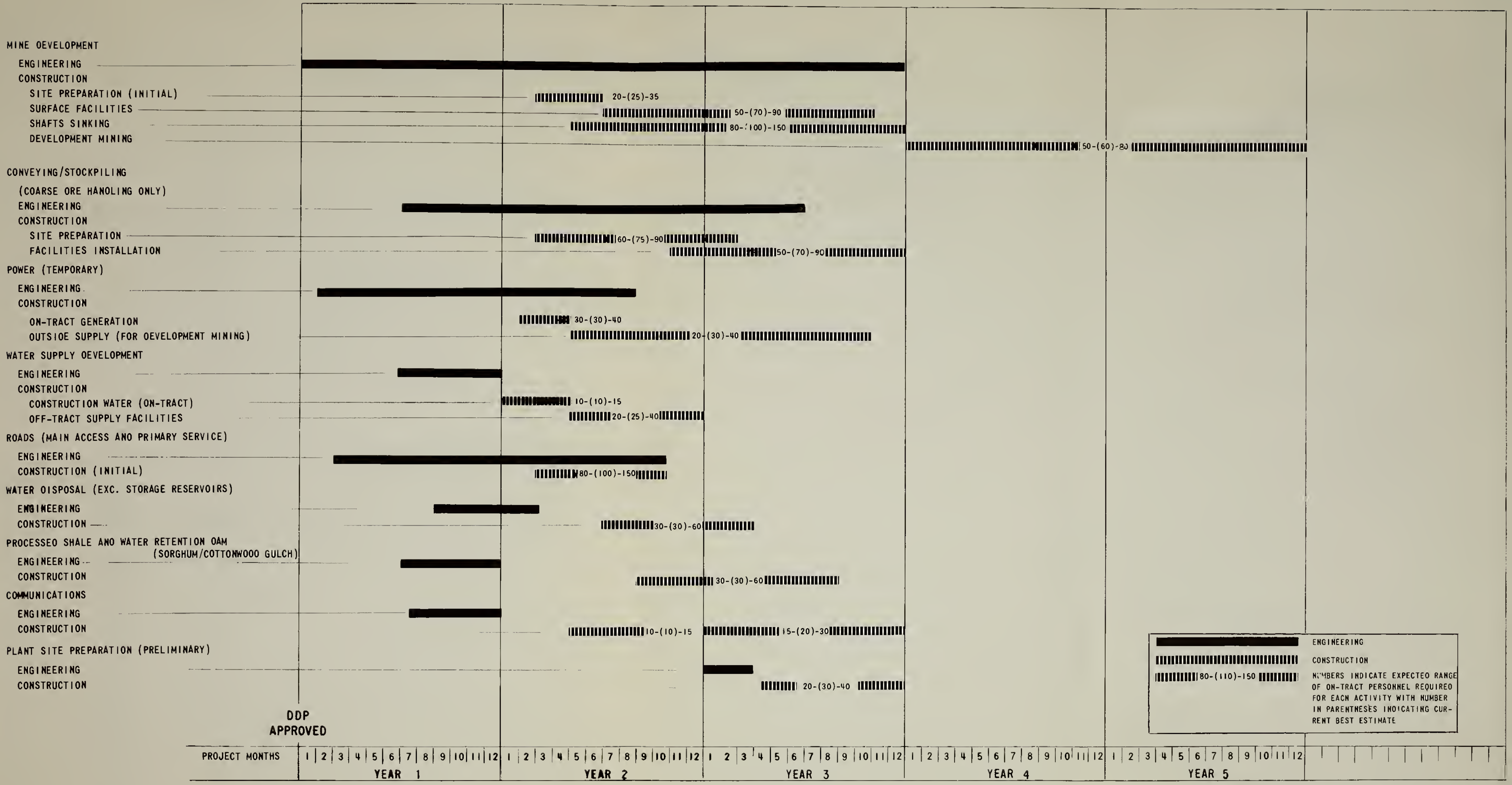
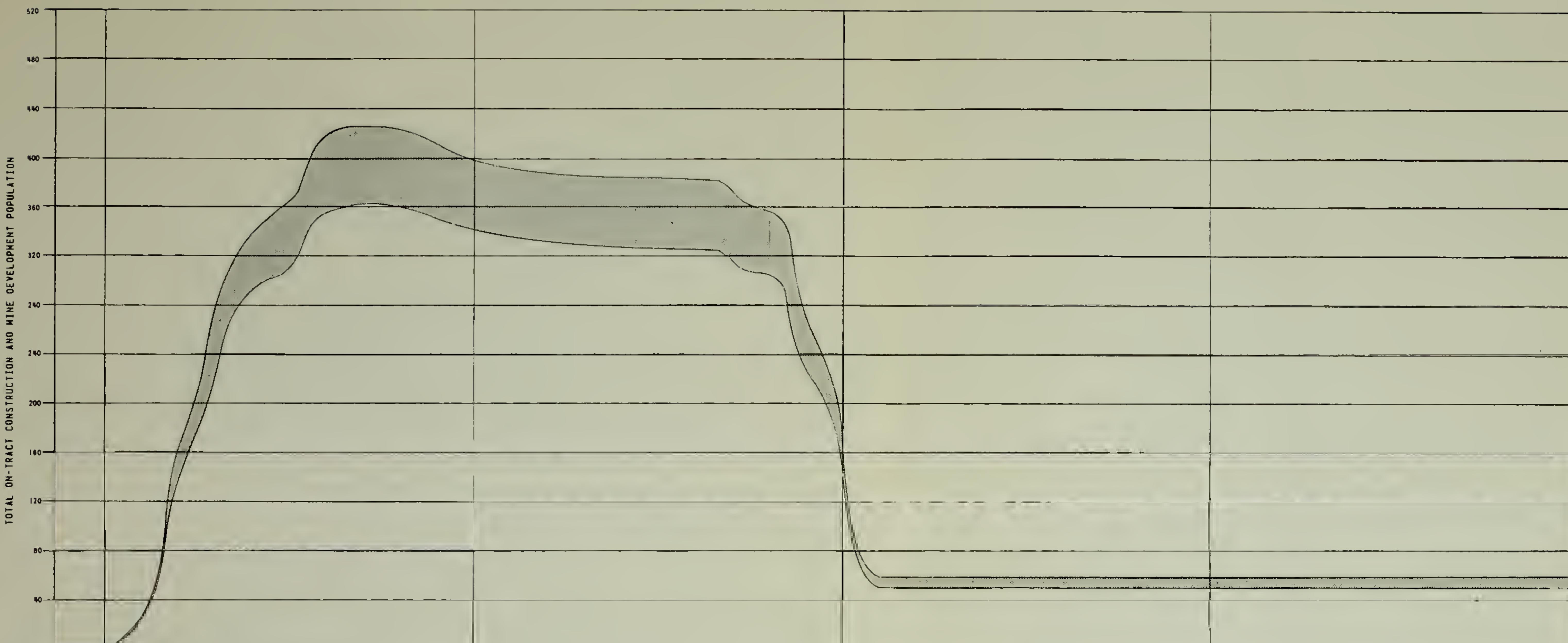


Figure II–1 PHASE I DEVELOPMENT SCHEDULE AND MANPOWER ESTIMATES

Figure II–2 PHASE I PROJECT PLOT PLAN



DDP APPROVED

PROJECT MONTHS	Y2-1	Y2-2	Y2-3	Y2-4	Y2-5	Y2-6	Y2-7	Y2-8	Y2-9	Y2-10	Y2-11	Y2-12	Y3-1	Y3-2	Y3-3	Y3-4	Y3-5	Y3-6	Y3-7	Y3-8	Y3-9	Y3-10	Y3-11	Y3-12
BOILER MAKERS																	3	3	11	14	14	14	14	
BLOCK MASON										5	5	5	5	5										
CARPENTERS		5	10	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	25	25	20	20	15	10
CEMENT FINISHERS			2	2	4	5	5	5	3	3	3	3	7	7	9	9	7	7	2	1				
ELECTRICIANS			5	20	20	20	20	20	20	21	25	25	25	25	30	25	25	25	25	30	25	25	25	15
IRON WORKERS			7	7	20	25	25	25	25	25	20	20	20	25	30	30	30	30	30	35	30	30	20	15
LABORERS		20	50	75	75	60	80	90	86	80	70	70	60	60	55	55	50	45	40	30	35	30	25	15
MILLWRIGHTS					5	5	5	5								10	14	25	30	27	25	25	20	13
OPERATING ENGINEERS	10	50	70	90	90	90	90	90	70	70	60	50	50	50	45	30	30	30	25	25	25	20	10	5
PAINTERS											10	10	10	10	10	10	10	10	10	10	10	10	10	10
PIPE FITTERS			15	16	30	30	30	30	16	16	21	21	21	21	15	16	25	25	35	35	35	35	25	10
TEAMSTERS		20	25	30	30	30	30	30	25	20	19	14	10	10	10	8	8	6	6	6	6	6	4	2
SHAFT SINKERS							45	45	85	85	85	85	85	85	85	85	85	85	85	85	85	85	45	45
PRODUCTION MINERS																								
SUPERVISORS AND CLERICAL STAFF	10	17	25	30	45	50	55	55	65	65	65	65	62	62	62	62	62	62	58	58	50	50	45	35
TOTAL	20	112	209	300	349	365	415	425	425	420	408	396	385	390	381	370	379	383	382	381	360	350	258	175

PROJECT MONTHS	Y4-1	Y4-2	Y4-3	Y4-4	Y4-5	Y4-6	Y4-7	Y4-8	Y4-9	Y4-10	Y4-11	Y4-12	Y5-1	Y5-2	Y5-3	Y5-4	Y5-5	Y5-6	Y5-7	Y5-8	Y5-9	Y5-10	Y5-11	Y5-12			TOTAL MAN MONTHS
BOILER MAKERS																											73
BLOCK MASON																											25
CARPENTERS																											560
CEMENT FINISHERS																											84
ELECTRICIANS																											496
IRON WORKERS																											524
LABORERS																											1276
MILLWRIGHTS																											209
OPERATING ENGINEERS																											1175
PAINTERS																											140
PIPE FITTERS																											523
TEAMSTERS																											350
SHAFT SINKERS																											1370
PRODUCTION MINERS	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37			888
SUPERVISORS AND CLERICAL STAFF	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22			1743
TOTAL	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59	59			9456

(Y = YEAR; YEAR 1 precedes Year 2 month 1.)

Figure II–3 PHASE I MANPOWER ESTIMATE AND SKILLS BREAKDOWN

Table II–1 PHASE I PROPOSED SURFACE DISTURBANCE BY YEAR

AREA DISTURBED (ACRES)

DDP APPROVAL

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to end of operation	Total by Activity
PHASE I												
Mine Surface Facilities		25-35										25-35
Coarse Ore Conveyor		5-10										5-10
Coarse Ore Stockpile (Initial)		35-40										35-40
Road Construction (New)												
-Primary Tract Access		40-50										40-50
- Dam Access		10-15										10-15
-Primary Coarse Ore Conveying/ Stockpiling		5-10										5-10
Dam Sites (Sorghum & Cottonwood Gulches)		15-25										15-25
Construction Water		5-10										5-10
Reservoir (Sorghum Gulch)		5-10	10-15									15-25
TOTAL BY YEAR		145-205	10-15									155-220

activities, with the current best estimate shown in parentheses. Actual numbers of workers will depend upon contractors selected, labor force availability and productivity and other factors. Many skills are used in connection with the work, and Figure II-3 represents a current best-estimate of the skills breakdown for Phase I. Figure II-3 also shows the total anticipated on-tract work force for Phase I with a peak labor force of approximately 425 workers occurring toward the end of the second year following DDP approval.

The first major activity during Phase I will be the sinking of entry shaft(s) which will require approximately 100 workers.

The current estimates of personnel required for shaft sinking and for surface construction activities are shown in Figure II-1. Surface construction includes mine site development, coarse-ore stockpile, roads, dam building and miscellaneous power, water and support activity.

Once the shaft sinking and surface construction has been completed, development mining and associated activities will commence. Approximately 60 people will be employed in development mining operations for a period of approximately two to three years (Figure II-1). Because of the specialized nature of some of the equipment to be employed, an operator training period will be required, and an early staff buildup of approximately 20 employees could precede mining by six months.

In addition to the manpower requirements set forth above, a field supervisory staff of both the Lessee and the contractors will be on-tract. This staff will be about 7% of the total personnel employed on-tract.

C. Engineering Design and Procurement

Following DDP approval, and assuming favorable political and economic conditions, Lessee will begin the engineering, planning and design work required for mine construction. This will include the preparation of engineering layouts and final designs, the evaluation of bids and proposals from suppliers and contractors, and the initiation of procurement contracts. Approximately one year will be devoted to this activity. During this period, a general contractor will be selected to carry out the Phase I field work. Lessee plans to pay this contractor in advance, prior to April 1, 1977, for a portion of the services to be performed on the Tract during the remainder of Phase I. This payment, along with other operational expenses incurred, will be applied as a credit against the fourth bonus installment, as provided for by the terms of the lease. Work performed on the Tract prior to the due date for the fifth bonus payment will be similarly credited against the payment. If necessary, in order to offset the entire bonus payment, additional contractor prepayments will be made before the fourth anniversary date. Field work on the mine development phase should commence approximately one year after DDP approval.

D. Mine Surface Facilities

The site of the mine shafts and mine surface facilities is shown in Figure II-2 and will cover an area of about 25 acres. Approximately 15 acres will be used during Phase I, and the remaining 10 acres will be stabilized pending use in Phase II. A balanced cut and fill method will be used in site preparation to minimize surface disturbance. Excavation, grading and filling will be carried out in accordance with the procedures and plans set forth in Section V. G., Overburden Management. The entire area will be secured by a fence around the perimeter.

The mine surface facilities site is located on the ridge between Cottonwood and Sorghum Gulches. This location minimizes the amount of clearing and excavation and thereby reduces land disturbance. The ridge area tends to be relatively flat, which reduces the amount of cut and fill. In addition, the ridge areas tend to have shallow, residual soils as compared to the thicker, more fertile alluvial soils of the valleys. Thus, location of mine surface facilities on ridge areas tends to minimize soil disruption.

Construction of the facilities on a ridge is also desirable from a geotechnical standpoint because the depth to competent bedrock is generally less than that found in the valleys. This is particularly important since major structures must be set on bedrock to maximize stability and minimize costs.

Prior to the leasing of the Tract, the vegetation on much of the Tract had been altered as a result of chaining activities carried out by the Bureau of Land Management. The plant and mine surface facilities are located in large part on chained areas of the Tract.

A ridge site location is the most desirable from a standpoint of minimizing the degradation of water quality. Placing the mine surface facilities in a valley would require stream diversion structures, even though the streams are mostly intermittent. Valley sites are always subject to flood hazards, whereas the ridge site tends to be the least vulnerable because the plant is located at a point where minimal watershed is disrupted. It is also easier to control runoff from various areas on the ridge site and direct this runoff into a pre-selected watershed. Most of such runoff will be directed to Sorghum and Cottonwood Gulches.

During Phase I the mine surface facilities including office-changehouse, warehouse, fuel supply, maintenance shop, electrical substation, parking, water handling ponds, material storage, storage yard, shaft headframes, mine utilities and rock handling bin, will be constucted. The general location and dimension of these facilities is shown in detail on the Phase I surface facilities plot plan (Figure II-4). Exact configuration and dimensions of these facilities will be defined during the Phase I pre-construction engineering activities.

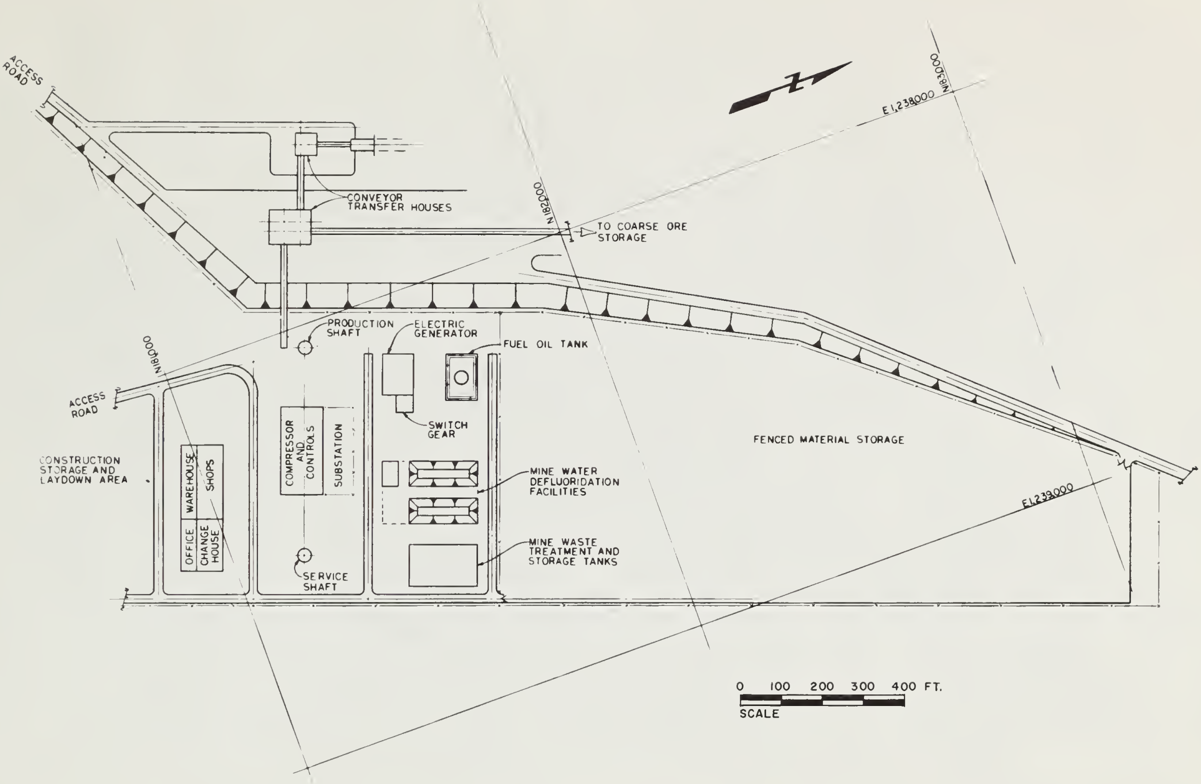


Figure II–4 PHASE I SURFACE FACILITIES PLOT PLAN

E. Mine Shaft Sinking

1. Introduction

At the site prepared for mine surface facilities the Lessee will construct one or more vertical mine shafts, approximately 30 feet in diameter each. The mine site location in relation to other Tract facilities is shown in the Phase I plot plan, Figure II-2. The shaft locations are shown in Figure II-5.

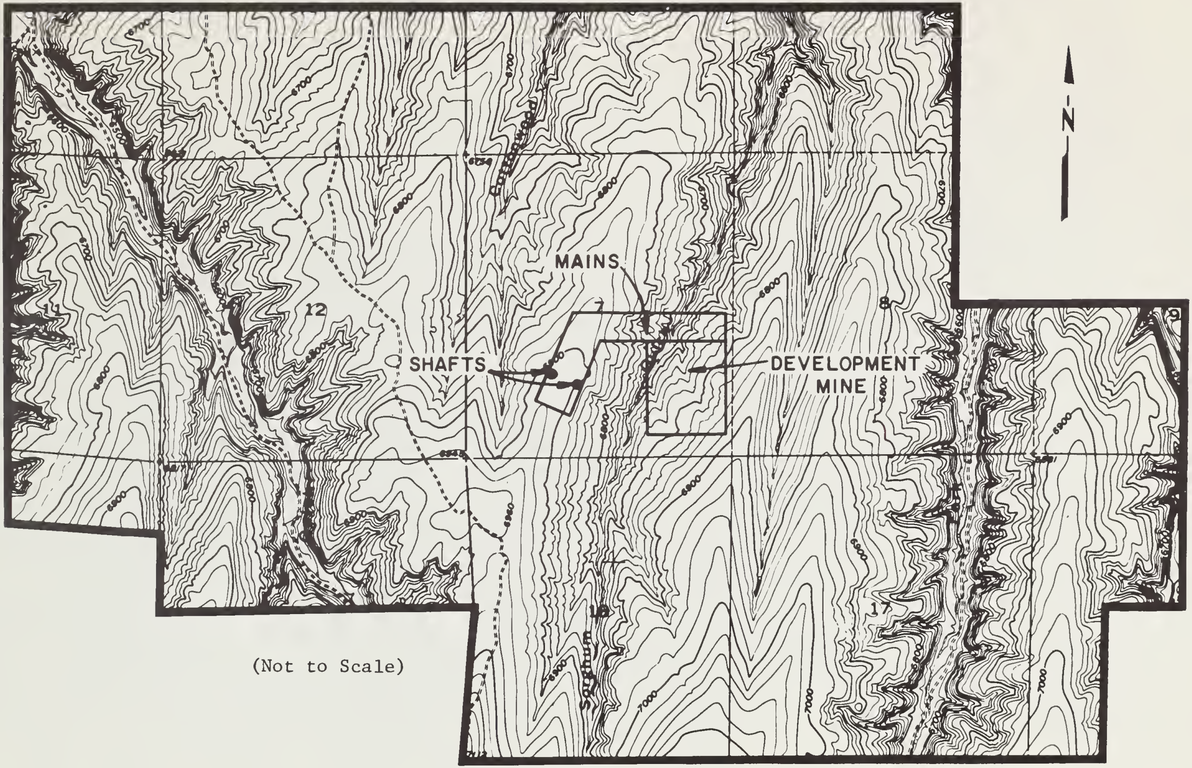
Four potential ways of entering the ore body have been considered. Access can be by way of an open pit, adit (horizontal entry), inclined shaft or vertical shaft. The first two methods are not feasible on the Tract because the mine zone is located at an average depth of more than 1200 feet and does not outcrop. Based upon information available to date, the vertical shaft method appears preferable to the inclined shaft method, primarily because the vertical shaft is significantly shorter. Also, penetrating horizontally bedded formations at an angle may cause additional problems, such as water inflow control.

2. Design

The preliminary design for mine access is based on developing two approximately 30-foot diameter vertical shafts, situated approximately 500 feet apart. During Phase I, one shaft would be used for ore production while the other would be a service shaft for men and materials. The shafts would also be used for ventilation, with the service shaft used for air intake and the production shaft for exhaust. Based on knowledge gained during Phase I, one or more additional production shafts may be required to be constructed in Phase II to achieve full commercial capacity and system reliability. Planned depth of the production shaft is approximately 1650 feet below a collar elevation of approximately 6900 feet, and depth of the service shaft below the same datum is approximately 1450 feet.

The site of these shafts is shown in Figure II-5 above. This site was selected because the location is near the center of the Tract in close proximity to the proposed plant site and on relatively flat terrain. The site is also compatible with the location of the coarse-ore stockpile.

Both shafts will be lined with poured concrete placed in 20- to 30-foot lifts. The shaft linings will be continuous except for station openings. The thickness of the lining will be determined as part of the detailed shaft design with a probable minimum thickness of about 12 inches. In addition to lining, both shafts may be sealed where necessary to a depth of about 1000 feet, through a formation referred to as the Four Senators zone, to minimize disturbance of upper zone aquifers and seepage into the shafts. Below this zone, shaft water inflow will be collected and pumped to the surface for disposal.



(Not to Scale)

Figure II–5 SHAFT SITE AND DEVELOPMENT MINE LOCATIONS

The production shaft is planned to be equipped with four skips of approximately 60-ton capacity each. The skips will be hoisted in balance by two friction hoists located in the headframe, as illustrated in Figure II-6, or ground mounted in a hoist house. Four skip loaders, equal in capacity to the skips, will be installed adjacent to the production shaft at a discharge elevation of approximately 75 feet below the mine floor, as illustrated in Figure II-7. The preliminary design is based on wire rope skip guides, except in the loading and dumping zones where steel guides will be used. Dust control measures such as water or dust suppressant sprays will be used as necessary in skip loading and dumping areas. A manway and utility lines (e.g., potable water, power and communications) will also be installed in the production shaft.

The service shaft will be equipped with a large service cage with a counterweight and a smaller auxiliary cage with a counterweight. All service shaft conveyances will travel on fixed guides. Both cages will be powered by friction hoists.

Contingent planning for an inclined shaft is being done by Lessee in the event that vertical shafts prove to be unfeasible. This alternative is not presently planned to be used but is being studied in the event it becomes economically or technically necessary.

3. Construction

The shaft construction will be performed by a shaft-sinking contractor using conventional drilling, blasting and mucking methods and equipment. The large size of the shafts will probably justify the use of double-drum hoists, if available, and multiple mucking units. Muck will be hoisted to the surface in buckets which will be dumped in the headframe where it will flow by gravity to a ground level surge pile. Special headframes and skips may be utilized during shaft-sinking.

About 170,000 tons of rock will be excavated from the proposed commercial production and service shafts. The excavated material will be loaded onto trucks, hauled to the Sorghum Gulch dam site or other areas and used as fill.

The long-term purpose of the Sorghum Gulch dam is to retain runoff water from the processed-shale pile in Sorghum Gulch. During Phase I, this dam will serve to retain runoff from the mine surface facilities and to store ground water produced during the shaft sinking and development mine operations. Due to the general lack of good quality rock material on or in the vicinity of the Tract, shaft rock material can be used advantageously for dam construction. Shaft muck may also be used for fill in the small runoff catchment dam to be built below the proposed coarse-ore stockpile, located in Cottonwood Gulch as shown in Figure II-2.

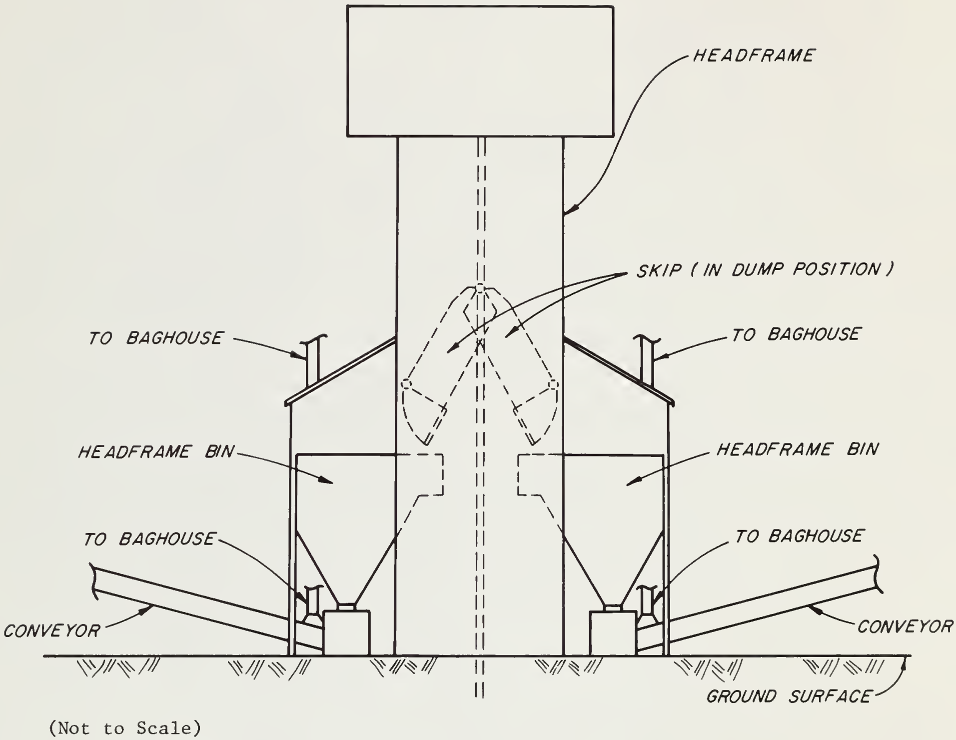
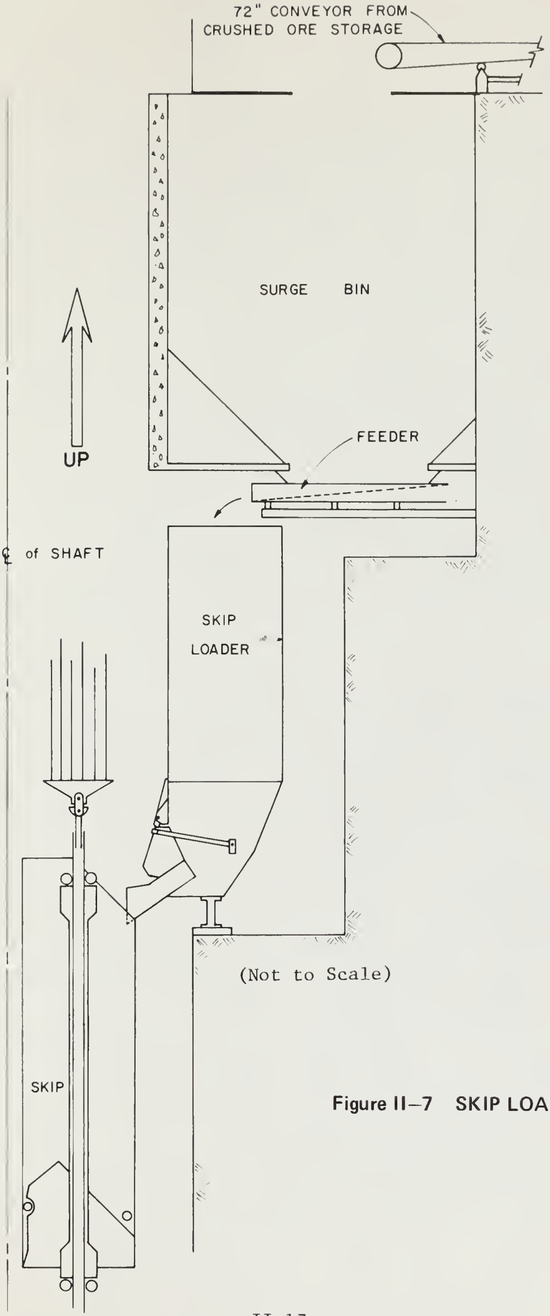


Figure II–6 HEADFRAME DISCHARGE STATION



(Not to Scale)

Figure II–7 SKIP LOADING STATION

If all the rock material produced from shaft sinking cannot be relocated in the areas discussed above, the excess rock will be transported to the proposed processed-shale disposal site in Sorghum Gulch. This choice will not be made until all other beneficial uses for this rock as fill have been explored. While a balance between rock removal and rock placement is desired, the timing of such rock excavations and placements is not always simultaneous. In such cases, the temporary storage of excess rock may be necessary in Sorghum Gulch for later use as fill material in Phase II plant construction.

F. Development Mine

After completion of the shaft-sinking operation described above, development mining will commence in the latter part of Phase I. The primary purposes of the development mine will be to obtain enough in-place mining information to determine the technical, economic and environmental feasibility of the commercial project and to develop a final design for the commercial mine. Information which must be obtained from development mining includes pillar strength and allowable roof spans, underground hydrology, equipment evaluation, and a study of air quality in the mine and appropriate air and water quality control procedures. This type of necessary information cannot be effectively measured by bore holes from the surface. It must be obtained by actual underground mining experience.

1. Mining Zones

The development mine will be in the Mahogany zone within the stratigraphic limits shown in Figure II-8. The Mahogany zone is the unit of principal commercial interest beneath the Tract because it contains the richest oil shale section in this part of the Piceance Creek basin. Beneath the Tract, the Mahogany zone ranges from 174 to 187 feet in thickness. The Mahogany zone is bounded at the top by a lean oil shale unit about 15 feet in thickness known as "A" Groove, and is bounded at the base by a lean oil shale unit about 20 feet in thickness called "B" Groove. The primary interval of commercial interest is a section ranging from 74 to 83 feet in thickness in the upper middle part of the Mahogany zone. The exact horizon to be mined has not yet been selected. Final selection will be made following final analysis of resource and structural data. No oil shale of potential economic interest is present above the Mahogany zone.

The oil shale section between the base of "B" Groove and the base of the Parachute Creek member is customarily referred to as the "lower oil shale zone." This section has been subdivided into a number of richness sub-units called R zones. In the north-central part of the basin, this interval is comprised almost entirely of rich oil shale. However, on the Tract, which is peripheral to the basin depocenter, the lower oil shales are much leaner in comparison. The R-4 zone contained in the lower oil shales may have some future commercial potential but is

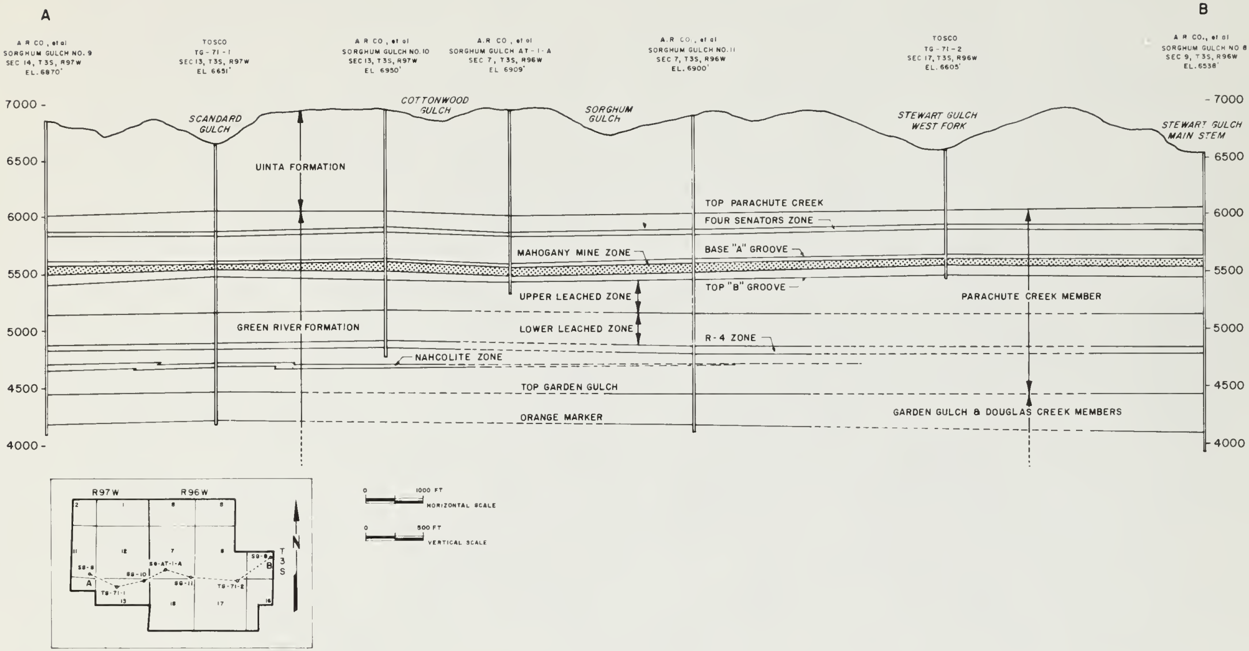


Figure II–8 EAST – WEST
GEOLOGIC CROSS SECTION – TRACT C-b

not considered for mining at this time (Figure II-8). Resource data for the lower zone has been obtained as part of the exploratory drilling, and a continuing evaluation of that zone as a commercial mine zone will be carried out as the project proceeds and as economic factors change. Any future decision to commercially mine the lower zone would be preceded by preparation of detailed plans and receipt of approval by the AOSS. Mining in the Mahagony zone is not expected to affect adversly the subsequent mining of the lower zone.

Total quantity of material recoverable from an underground mining operation depends upon several factors, including depth of deposit, grade of deposit, rock structure and geologic structure. In room-and-pillar mining, some fraction of the ore body must be left as pillars to support the mine roof and all overlying beds. This can range from as little as 20% in shallow deposits of highly competent rock, to as much as 80% in deeper, less competent rock. Also, as the thickness of the mining zone increases, the area of the support pillars must increase and the fraction of the total zone which can be extracted decreases. In addition, the grade of the oil shale within the Mahogany zone beneath the Tract is not uniform vertically, and increasing the thickness of the mining zone decreases the average grade of shale obtained by inclusion of leaner rock. The development mine will be used to explore these considerations by testing various mining heights and room sizes to optimize resource recovery.

2. Mine Design

As presently envisioned, the development mine will encompass an area of approximately 1300 feet by 1300 feet (about 40 acres), located on the Tract as shown in Figure II-5. A development mine of this magnitude is necessary to insure that the full overburden load will be exerted on the pillars. The development mine will be located in the Mahogany zone, completely outside the pillar area which lies beneath the processing plant and the shafts. The exact site will be determined prior to shaft-sinking by analysis of data from mine design studies. Up to four different mining heights will be considered in the development mine design. Depending upon the mining height, pillars are expected to range from 50 feet by 50 feet to 150 feet by 150 feet. Room spans will probably fall within the range of 40 feet to 60 feet. The proposed layout of the development mine is shown in Figure II-9.

It is estimated that the development mining operation could span a 2-to-3 year period beginning in Phase I and possibly continuing into Phase II, and produce approximately 3,000,000 tons of oil shale. An additional 500,000 tons of shale will be produced during excavation of the main entries.

The ore will be conveyed from the development mine headframe to the coarse-ore stockpile area, which will be located in the same area as the

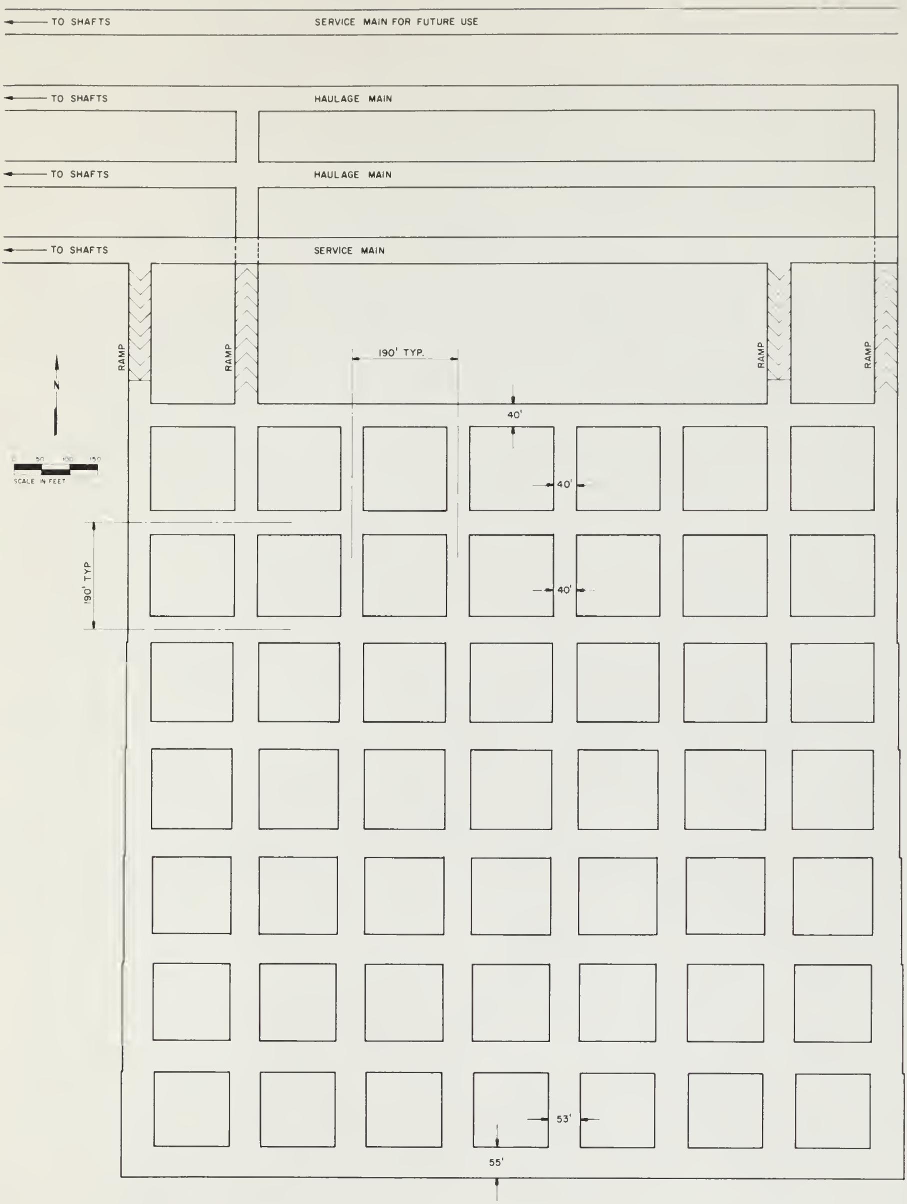


Figure II–9 DEVELOPMENT MINE LAYOUT

commercial stockpile at the head of Cottonwood Gulch, as shown in Figure II-2 above. The ore will be dumped and spread by a crawler-type tractor. The estimated maximum pile dimensions will be about 1200 feet long by 1200 feet wide by 60 feet high, covering approximately 35 acres of land. During the early stages of mining, the ore may be trucked to the pile until the conveying system is installed.

3. Mining Cycle

The development mine will be excavated using conventional large-scale room-and-pillar mining techniques as illustrated in Figure II-10. If a 60- or 75-foot mining height is chosen, at least two passes will be made to mine the ore body. In that case, the mining cycle will involve one pass using upper-level or face-mining equipment, followed by one or more passes with lower-level or bench-mining equipment. If a 35-foot mining height is chosen, only one pass would be required, using the upper-level equipment. If a 45-foot mining height is chosen, either a single or multiple-pass approach may be used.

The upper-level mining cycle will proceed as follows. First, the face will be drilled using a face-drill jumbo. An upper-level charging rig will then load the drilled round with explosives. The round will then be blasted during the next shift change. Fly rock from the blast will be cleaned up with a front-end loader and the blasted rock or muck will be wet down by a water truck to control dust. The rock will then be loaded into trucks by a front-end loader for haulage to the primary crusher. When the distance to the crusher is small, a front-end loader might haul directly to the crusher without using trucks. After the blasted rock is completely removed, the ribs (sides), back (roof) and face will be scaled to remove any loose rock. The mining zones being considered are bounded at the top by distinct parting planes. As these parting planes normally pull well, minimal scaling is required and scaling can safely follow loading in the work cycle. Following the scaling operation, a front-end loader will clean up the scaled material. The back exposed by the blast will then be roof-bolted in accordance with accepted safety standards. If needed, drain holes to relieve hydrostatic pressures above the roof and below the floor will then be drilled. Instruments to monitor rock behavior will be installed as required. When this is done, the cycle will be completed and the face readied for drilling of the next round.

The lower-level cycle, if used, will begin when sufficient upper-level mining is completed to allow both cycles to proceed without interference. The lower-level cycle will start with the drilling of multiple vertical holes from the top of the mine bench. These holes will then be loaded with explosives and blasted during a shift change. This will be followed by fly rock clean up and muck pile wetting. The muck will be loaded using the same method as in upper-level loading. The area will then be scaled and the scaled rock cleaned up. After installation of any rock mechanics instrumentation, the bench would be ready for the cycle to begin again.

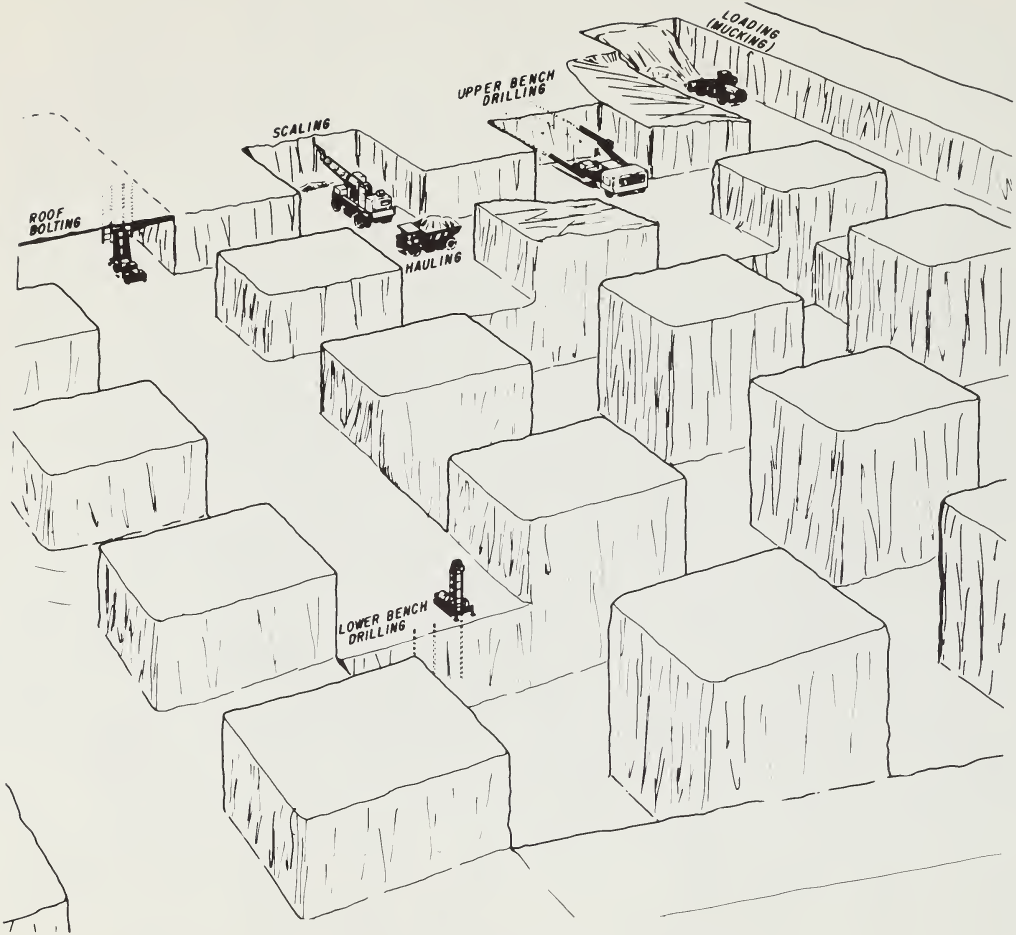


Figure II–10 ROOM-AND-PILLAR MINING CONCEPT

Figure II-9 shows the expected orientation of the development mine. Final orientation of the development mine will be based on analysis of data from the mineability study. Final room-and-pillar orientation for the commercial mine will be based upon observed structural geology in initial development mine openings and on in-situ (in-place) stress measurements.

4. Mine Development Programs

Since the development mining program will be the last step prior to commitment to a commercial mining operation, a number of comprehensive investigations will form an integral part of the development mining operation. These programs include: 1) hydrologic evaluations, 2) mine dewatering, 3) rock mechanics, 4) equipment development, 5) gas evaluation, and 6) mine air quality. They are described in the following sections.

Hydrologic Evaluations. The purpose of hydrologic evaluations in the development mine will be to provide design information for commercial scale mining and to insure safe and productive operation of the development mine. The following information will be obtained:

- measurement of mine water inflow
- correlation of mine water inflow with geologic parameters
- Tract-wide correlation of mine water inflow with bore hole information
- evaluation of vertical permeability above and below the mine
- evaluation of hydrostatic pressures above and below the mine
- evaluation of hydrostatic pressures in mine pillars
- effects of development mine induced stress changes on permeability values
- effects of development mine flow on the overall hydrologic regime.

These evaluations will be made using standard techniques. Measurement of water inflow will be done as water is pumped from the mine. The need for and effectiveness of drill holes to relieve hydrostatic pressures will be evaluated by installation of piezometers at various depths in the mine roof, floor, pillars and ribs. Effects on the overall hydrologic regime will be measured by surface-monitored bore holes.

Mine Dewatering. In the conduct of development mining activities, ground water flow into the development mine is anticipated. As in any mine operation, the water must be intercepted or collected, removed from the mine and used or disposed of (see Figure II-11). The collection and accumulation of water in the development mine will be conducted in a manner allowing accurate determination of desired hydrologic information. Water will be removed from the development mine by high-head pumps and disposed of as described below.

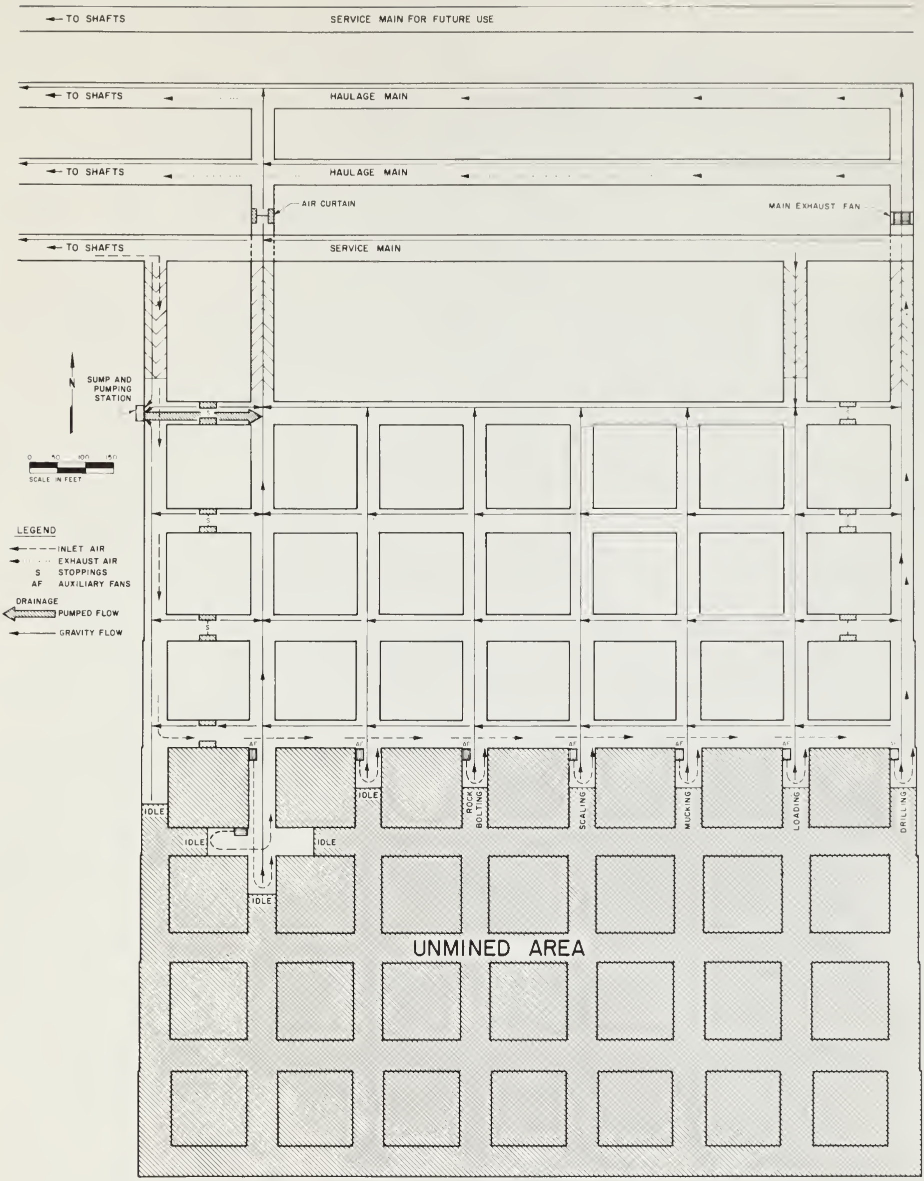


Figure II–11 DEVELOPMENT MINE VENTILATION AND DEWATERING SYSTEMS

Rock Mechanics. The purpose of rock mechanics investigations at the development mine will be to provide design information for use in commercial-scale mining as well as to insure safe operation of the development mine.

Information will be obtained on:

- correlation of underground geologic structure with bore hole data
- pillar design
- safe roof span
- mine orientation
- in-situ (in-place) principal stresses
- mine roof location
- roof bolt design
- blast effects on mine structure
- effect of rock quality on pillar behavior

The rock mechanics program will use evaluation techniques similar to those employed at other mining operations. Pillar and in-situ stresses will be determined by use of the United States Bureau of Mines over-coring technique. Stress changes will be monitored by photoelastic strain gauges. Roof and floor behavior will be monitored by extensometers and sagmeters. Geologic structure will be mapped. Blast effects will be evaluated by stratascope examination, core logging and geophysical monitoring. Surface effects will be monitored by a precision level network and by bore hole monitoring. Interpretation of results will be made with the aid of computer models.

Equipment Evaluation. The purpose of the equipment evaluation program at the development mine will be to develop and evaluate equipment for use in commercial oil shale mining. Test programs will be set up for each type of equipment and will include time studies, operating cost evaluation, maintenance cost evaluation and safety evaluation.

The equipment selection for the initial efforts will be based on the determinations made as a result of previous oil shale mining activities and the available data from the Tract.

Much of the equipment considered for selection is commonly employed in the mining and construction industry or incorporates minor variations on such equipment. The specialized mining equipment such as drill jumbos, roofbolters and explosive loaders will be units of proven concept in the mining industry chosen specifically for application to the development mine. All underground mobile units employed will be diesel powered and equipped with catalytic exhaust conditioning systems.

Though production capacity will not be a primary objective of development mining activity, minimum quantities of equipment and spares will be employed to insure continuity of operation. During development mining activity, detailed records of operation and maintenance of all equipment will be kept. These records, together with engineering studies of the equipment during this phase, will form the basis for initial selections for commercial operations.

Gas Evaluation. Since the oil shale on the Tract is a hydrocarbon material occurring in a sedimentary deposit, the potential exists for methane gas occurrence. Experience in oil shale to date has not indicated that methane gas will occur in sufficient quantities to cause problems in oil shale mining.

A gas sampling program has been conducted in conjunction with core hole drilling on-tract. Various gas sampling techniques, including direct core testing, grab sampling and continuous gas chromatography have been used and are described in the Quarterly Data Reports and the Summary Data Reports. Detailed evaluation of the data from this program is currently underway. No firm conclusion can as yet be drawn. Present preliminary indications are that the potential mine zones appear to be essentially free of methane gas, although small amounts have been detected in core holes. However, in order to insure safe conditions and to anticipate potential problems, a gas evaluation program will be carried out in the development mine.

The purpose of the gas evaluation program will be to provide design information on potential gas inflows in commercial-scale mining as well as to insure safe operation of the development mine. The following information will be obtained from the development mine gas evaluation program:

- source of gas inflow into the development mine, if any
- magnitude of gas inflow into the development mine, if any
- composition of any gas inflow into the development mine
- amount of gas released from in-place shale during mining
- amount of gas released by mine dewatering
- correlation of development mine results with data from the bore hole gas evaluation work
- potential for effective control of mine gases

In order to achieve the above objectives, ventilation air will be continuously monitored for gas content. Portable methanometers will be used to evaluate localized areas. Gas will be separated from mine water inflow and measured. If necessary, drill holes will be used to evaluate gas sources. If required, degassing and sealing techniques will be evaluated.

Air Quality. An air quality program will be conducted to provide information concerning dust and fume concentrations and properties for use in commercial mine design, and to insure safe and healthy working conditions in the development mine. The following information will be obtained from the development mine air quality program:

- particulate loadings generated by each operation in the mining cycle
- particle size distribution for dust generated by each operation
- effectiveness of dust control measures
- free silica content and other potentially toxic constituents of mine dust
- diesel engine emission characteristics
- effectiveness of diesel engine emission controls
- ventilation required for mine environmental control
- potential explosivity of mine dust

Information on mine dust will be obtained (by the use of dust-measuring equipment) to determine the total dust load, the dust particle size range and the respirable dust fraction total, in conjunction with various dust control methods. Free silica content will be evaluated by laboratory testing of collected samples. Information on exhaust emissions will be obtained using standard gas measuring equipment and techniques to sample mine air and equipment exhaust during mine operation. All of the above information will be correlated with ventilation measurements made concurrently. Explosivity will be determined on dust samples collected during the dust sampling program.

Ventilation. The purpose of the development mine ventilation system will be to provide a safe, healthy and comfortable working environment. The system design will comply with all federal and state mine laws. The system, which will be designed on the basis of diesel horsepower underground, number of men underground and minimum air velocities, is shown in Figure II-11. Ventilation air flow rates will be on the order of 200,000 to 300,000 CFM. Fresh air will be carried down the service shaft and through service mains to the development mine, circulated through the mine, and returned via haulage mains to the production shaft, where it will be carried to the surface. An exhaust system with a fan on the surface will probably be used. During the winter months, the intake air will be heated to maintain the temperature in the service shaft above freezing. Underground air flow will be controlled by utilizing portable fans, stoppings and air curtains to direct air to the appropriate working areas.

Emissions of hydrocarbons and carbon monoxide from diesel equipment will be minimized by use of catalytic exhaust conditioners. The amount of NO_x produced will be minimized by good maintenance procedures. Proper mixing of ammonium nitrate fuel oil (ANFO) explosives will minimize CO and NO_x generation in blasting. Dust suppression techniques such as wetting of haulage roads and muck piles and water sprays at truck dumping and primary crushing operations, will be used to minimize fugitive dust generation in the development mine. A typical muck pile will be wetted three times during the loading cycle with a quantity of 600 gallons per application.

5. Underground Mine Services

Maintenance. During Phase I, the maintenance shop will be located on the surface facilities. Minor repairs and servicing to underground equipment will be made using a field mechanic's truck similar to those used by heavy equipment dealers for field service. Equipment requiring service will be parked in a non-active area of the mine. Portable lights will be used to provide adequate lighting for the mechanics during the repair operation. Major equipment repairs and overhauls for specific components will be done in the surface shop. The components will be disassembled and brought to the surface for overhaul. After overhaul, they will be returned underground and reassembled.

Waste Disposal. Waste disposal plans for the development mining operations are summarized below. A more detailed discussion of the specific disposal procedures and plans is given in Section V. I., Disposal of Other Wastes.

Underground sanitary facilities will be provided for employees. Portable units will be located near all active mining areas and crushing stations. The sewage from these units will be pumped into holding tanks. The holding tanks will then be transported to the surface and discharged into a package sewage treatment plant on the surface. For Phase I, the sewer system will be an aerobic system. This system will have a larger capacity than the maximum for the anticipated numbers of people required during Phase I. For the commercial phase, the system will be expanded to commercial size or tied into the central sewage system for the plant complex.

Liquid petroleum wastes such as used motor oil generated during development mining will be collected and stored in holding tanks. These tanks will then be transported to the surface via the shafts. The wastes will then be combined with other liquid petroleum wastes for disposition.

Solid waste and garbage from the development mine will be collected and transported to the surface. The solid waste and garbage will then be disposed of along with other solid wastes.

The solid waste disposal program will be designed to meet all governmental regulations and Lease Stipulations and be in accordance with good engineering practices.

G. Utilities and Fuel

1. Electric Power

Electric power will be required in the development mine for underground crushing, hoisting, ventilation, lighting, mine dewatering, communication, maintenance facilities and other general services.

Table II–2 POWER REQUIREMENTS DURING DEVELOPMENT MINING

	Horsepower	Load, KVA
General Services (includes surface and underground facilities)		600
Sinking Hoists	4000	3000
Underground Crusher	500	375
Ventilation	600	450
Pumping	750	575
Totals	5850	5000

Preliminary estimates of the power requirements for the above uses are outlined in Table II-2. During the initial period of Phase I, power will be generated on-site with portable generator sets totaling about 10,000 HP. Commercial power supplies are presently being investigated and will be brought to the Tract as soon as all arrangements and construction can be completed.

2. Water

Water for use in dust control and road maintenance will be collected in sumps in the development mining area. This water will then be pumped to the location where it will be used. Clean or potable water will be piped down from the surface facilities via the service shaft and distributed in pipes to the point of use. The water containment, treatment and disposal system to be used during Phase I is described in detail in Section II. L. Any water removed from the mine will be handled in that system.

3. Lighting

High intensity lighting will be located in and around all surface structures, shaft stations, shop facilities, dumping and crushing facilities, electrical transformer and switch stations, walkways, stairways and office facilities. Active working areas will be properly illuminated. All persons underground will have personal cap lamps of an approved type to supplement the lighting facilities installed on the mining equipment.

The lights and lighting in the development mine will be designed and installed in such a manner as to meet or exceed all applicable federal and state regulations and requirements.

4. Communications

The communications system for the development mine will consist of a standard hard-wired mine telephone network with extensions located at the primary work areas such as crusher stations, shaft stations, emergency facilities, storeroom and offices. This system will be tied into the surface telephone network via telephone wires in the shafts.

The development mine facility will also be used to test other underground communication systems. Such systems will include high-frequency and low-frequency radio systems as well as combination radio and hard-wired systems. Several combination systems using "leaky" coaxial cables and directional antennas have previously been used in underground mines. Feasibility studies are underway to determine if a total low-frequency radio system could be adapted for underground use. The data from these tests will be used to design the commercial communications system.

In addition, visual, audible or olfactory mine alarm systems will be used to notify mine personnel of emergencies that might occur in the mine.

5. Fuel

With the limited amount of equipment which will be employed underground during development mining activities, daily consumption of diesel fuel will not exceed a few hundred gallons. The mine fuel tank truck or fuel tank trailers will be filled at the surface storage tanks and subsequently will be transferred underground on the mine service cage on a routine schedule to insure the operating objectives of a minimum transfer frequency and minimum storage underground. Fueling operations shall be conducted only in designated approved areas selected with regard to security, ventilation and employee safety. The dispensing, transfer and storage of fuel will comply with all applicable federal and state regulations.

H. Crushing and Conveying

During the three-year development mining period, approximately 3,000,000 tons of oil shale will be mined from the test area. Also, an additional 500,000 tons will be produced from the development of access ways and adequate maintenance, storage and service areas. Mine production during this period will be on the order of 5,000 to 6,000 tons per day, assuming a 5-day, 10-shift per week production schedule is used.

Material produced during the development mining activity will be hoisted to the surface for stockpile storage. To facilitate handling, run-of-mine material will be crushed to a maximum size of 6 to 12 inches by a primary crushing installation located underground.

Size reduction of the run-of-mine material will be accomplished by a single primary crusher of either impactor, toothed-roll or feeder-breaker design. The final selection will be based on a detailed analysis of the operational and maintenance characteristics of the considered units. Feed to the primary crusher will be grizzled (sized) and the oversize will either be broken on the grizzly by a pneumatic breaker or a hydraulic breaker mounted on a hydraulic boom or removed by front-end loader for secondary blasting. The primary crusher will be replaced by two larger commercial-sized units prior to initiation of Phase III.

An average crusher throughput rate of approximately 450 tons per hour will be required to handle the development mine production during two 6.5-hour crushing shifts per day. A crusher capacity in excess of the average tonnage requirements is planned to accommodate the variation in feed rate attendant to the mining activity.

The primary crushing facility will be located in the exhaust air circuit in close proximity to the hoisting shaft to minimize the transport distance from the crusher to the shaft and eliminate the circulation of fugitive dust through the mine ventilation circuit. Dust suppression and/or collection equipment would also be used to minimize dust generation.

Run-of-mine material will be transported to the crusher from the mining face by rear-dump haulage trucks and discharged on the grizzly. Adequate capacity will be included in the surge hopper ahead of the crusher to allow discharge from more than one haulage unit without delay and to allow controlled feed to the crusher for operational efficiency.

The product from the primary crusher will be carried from the bottom of the crushing installation by a short "speed-up" conveyor belt and transferred to the primary coarse-ore conveyor for transport to the underground ore storage pocket at the hoisting shaft. Adequate storage capacity in the ore storage pocket will be included to allow at least two hours of unrestricted operations in the event of delay encountered in the mining, crushing or hoisting operations.

I. Alternate Mining Methods

The Lessee has selected the room-and-pillar mining technique for use on the Tract because it is the only demonstrated and proven method of oil shale extraction. Other mining methods that could theoretically be used to extract oil shale on the Tract include: longwall mining, long hole blasting, continuous mining, block caving, open-pit mining and in-situ processing. These methods and their advantages and disadvantages in mining oil shale in the Piceance Creek basin are discussed in the following sections. In order to achieve maximum utilization of the resource through increased recovery, adoption of one of the alternate mining methods described below or a modification of the room-and-pillar method may be required. These modifications may increase the potential for surface subsidence.

1. Room-and-pillar Mining

The C-b Shale Oil Project has initially selected the room-and-pillar mining method, in which multiple crosscuts and rooms are mined while the roof and walls are supported by pillars of rock. Ore bodies suited to room-and-pillar mining are sedimentary deposits that: have not been folded or deformed, have strong or moderately strong rock for pillars, have moderate to strong rock for roof and floors, are relatively flat lying and are of considerable extent in area.

The major advantages of room-and-pillar mining are:

- highly flexible in that it can be modified easily throughout the life of a mine to suit new conditions, equipment or new technological developments
- adaptable to a high degree of mechanization
- high degree of productivity because of the number of working areas available
- relatively easy to ventilate
- mine development is a production operation since it also takes place in the mining zone
- the mine can be designed to minimize the possibility of surface subsidence

The major disadvantages of room-and-pillar mining are:

- high-cost system for roof support
- relatively low extraction ratio

The overburden above the proposed mining zone ranges from 900 to 1300 feet. Preliminary rock mechanics studies made on core samples from the exploration program on the Tract indicate that the overall extraction ratio would be in the 30% to 50% range, depending primarily on the height of the mining zone. Greater extraction ratios would be possible if a caving method were subsequently utilized. Room-and-pillar mining will allow return to mined-out areas to exploit the remaining resources in the future. Room-and-pillar mining does not preclude later development of over and under lying oil shale zones.

The primary reason for selecting room-and-pillar mining is that it is the only proven mining method based on actual previous experience in oil shale mines. In addition, the proposed mining zones on the Tract meet all the general requirements for room-and-pillar mining.

2. Longwall Mining Method

Many ore bodies that can be mined with the room-and-pillar mining method can be extracted by the longwall method. Theoretically, this is true for the ore body on the Tract. However, the present range of mining zones for the Tract of 35 to 75 feet in thickness is much thicker than the nominal 5 to 10 feet which can be removed with present day longwall equipment. A mining zone projected for the Tract would require development of special supports, mining equipment and techniques which could require many years of research.

The longwall method consists of mining a straight face of at least 75 yards in length while supporting the roof of the mined-out area immediately adjacent to the face with hydraulic jacks or yieldable props. The jacks or props are advanced as the mining face advances, allowing the roof area behind the jacks to subside and cave in a controlled manner into the mined-out area.

Since this method is designed to have the mined-out areas cave in as the mining front advances, there are no pillars of ore left behind for roof support. Consequently, the extraction ratio in the 5- to 10-foot mining horizon is in excess of 90%. As a result of the extensive caving induced by the longwall method, it would be impossible to return to the same mining zone at some later point in time in an effort to recover the leaner oil shales in the horizons above the mined-out area.

The major advantages of the longwall mining method are:

- extraction ratio in excess of 90%
- adaptable to mechanization
- highly productive mining method

The major disadvantages of the longwall mining method are:

- technology is not presently available for mining heights in excess of 10 feet
- subsidence will occur and may affect groundwater
- potential mining zones above the mined-out area are broken and hence may be unrecoverable with known underground mining techniques

3. Long Hole Blasting

This method calls for a series of long blast holes being drilled from a central drift, much like the spokes of a wheel. The holes are charged and blasted. The broken rock is removed through drifts underneath the mining zone.

The major advantages of long hole blasting are:

- high degree of safety for workers
- recovery potential approaches 100% in the selected mining horizons

The major disadvantages of long hole blasting are:

- surface subsidence may occur and may affect groundwater
- mining zones above the mined-out area would become unrecoverable
- because the drifts are located beneath the mining horizon, generally in waste rock, large amounts of this rock are generated and require disposal on the surface

4. Continuous Mining

One possible direction which oil shale mining will take in the long term is a method which can utilize continuous mining machines. The machines have not yet been developed, but increasing knowledge of oil shale characteristics indicates that development will probably occur. The first application will probably be an adaptation of room-and-pillar mining.

The major advantages of continuous mining are:

- continuous mining machines are applicable to either room-and-pillar or longwall techniques
- less equipment needed in the overall mining scheme
- high degree of safety for miners

The major disadvantages of continuous mining are:

- not developed for oil shale mining
- breakdown of equipment could severely disrupt mine production

5. Block Caving

In block caving, a thick block of ore is partially separated by a series of drifts. An undercut is made by removing a slice of ore. The isolated block then caves under its own weight and the ore is removed. The continuous removal of the ore assures continued downward movement of the original isolated block.

The major advantages of block caving are:

- extraction ratios could approach 100%
- no waste rock produced

The major disadvantages of block caving are:

- surface subsidence will occur and groundwater would be affected
- block caving technology has not been applied to oil shale

6. Open-pit Mining

Open pit mining does not appear to be an economically viable or environmentally acceptable method of developing the Tract due to a high overburden/ore ratio. Overburden across the Tract is thick, averaging more than 1200 feet. The potentially extractable interval (containing 30 gallons per ton of shale) is relatively thin, averaging on the order of 150 feet. On this basis, the overburden/ore tonnage ratio is about 11:1. For every ton of ore that would be processed, more than 11 tons of overburden would have to be mined and disposed of. This would be prohibitive both economically and environmentally.

As discussed in the Geology and Resource section (Section VIII), no potentially mineable oil shale is present above the Mahogany zone. Figure II-12 shows the overburden thickness to the top of the undergound mine roof which is about 30 feet below the top of the Mahogany zone. As shown on the map, overburden ranges from about 900 to 1300 feet in thickness. Because of the need to slope the pit walls to maintain stability, approximately 40% of the Mahogany zone will not be accessible by open pit methods.

Figure VIII-11 in Section VIII shows the vertical distribution of oil shale beneath the Tract. As seen on this illustration, most of the richer oil shale is restricted to the Mahogany zone. Depending upon location beneath the Tract, this unit contains up to 150 feet of shale averaging 30 gallons per ton. Although some sections below the Mahogany zone, such as the R-4 zone, have thin intervals which approach 30 GPT in richness, these units are separated by substantial thicknesses of lean oil shale. Since it is not presently considered possible to economically process this lean shale, development of the lower zones does not appear feasible by surface mining.

The advantages of open-pit mining are:

- above ground operations as opposed to underground operations
- larger equipment can be used, reducing total manpower requirements

The disadvantages of open-pit mining are:

- not economical to remove 900 to 1300 feet of overburden on the Tract
- disposal of this much overburden is not feasible and would be environmentally disruptive
- disruption of aquifer system to pit depth

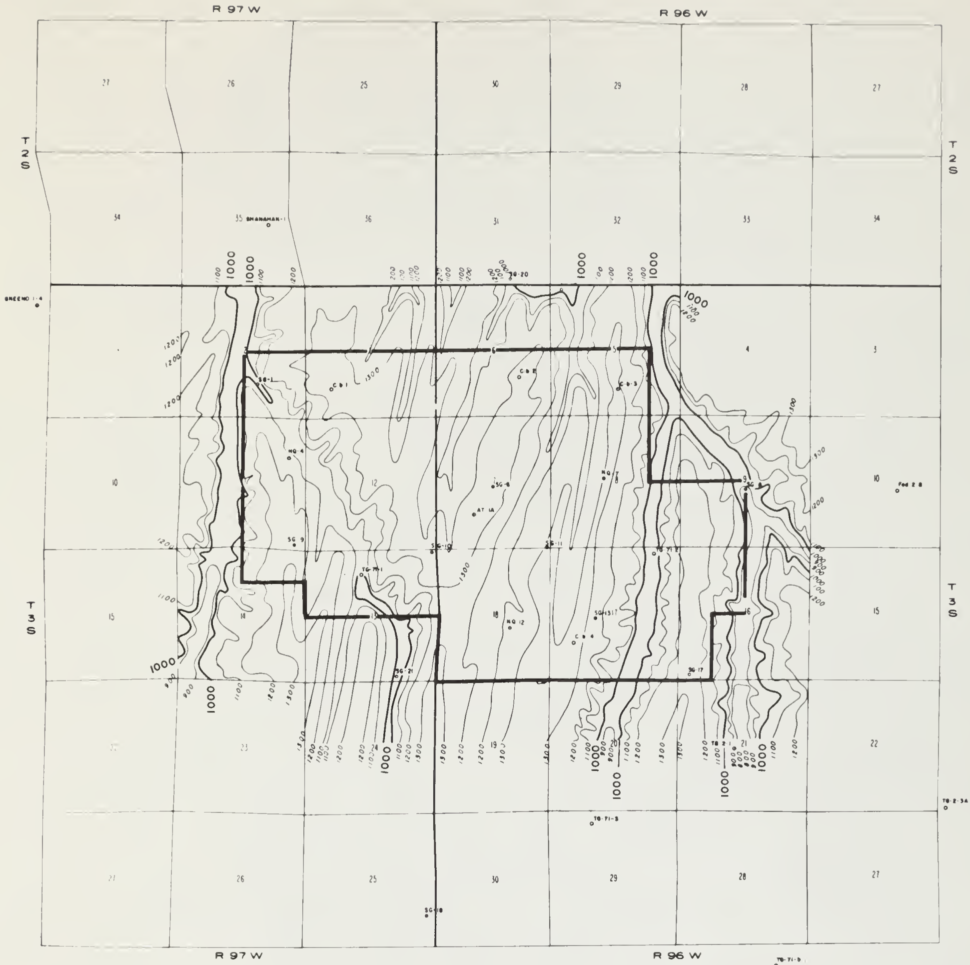


Figure II–12 PRELIMINARY ISOPACH OF OVERBURDEN SURFACE TO MINE ROOF – TRACT C-b

7. In-situ Processing

In-situ, or in-place, processing involves the underground retorting of oil shale by such means as combustion in the formation or the introduction of hot natural gas or superheated steam. The products of in-situ retorting, shale oil and low BTU gas, are recovered underground by various methods and sent to the surface for further processing or upgrading. Although a number of experiments have been or are being conducted by the federal government and industry, the commercial feasibility of this technique has yet to be demonstrated.

Because in-situ processing is still in the experimental stage, it is not considered a viable alternative to the commercial development of the Tract by the methods set forth in this plan. However, the process is not incompatible in concept with underground mining. It is possible that a system could be devised whereby the richer oil shales could be first removed by mining as described in this plan. This would provide the void space necessary for rubblizing the oil shale by caving. Subsequently, using a modified in-situ technique for secondary recovery, the fragmented oil shale chimneys could be retorted in place. However, before a combined process can be considered, successful in-situ development first must be realized.

J. Access and Service Roads

Construction of a new all-weather access road with a design maximum grade of 7% to connect the plant site with the Piceance Creek road will be located immediately west of Cottonwood Gulch as shown in Figure II-2. Consultants have recommended this route in preference to other routes, one of which is the existing Scandard Gulch ridge road.

In selecting the road location, environmental as well as economic and safety factors were considered. Several routes were selected and evaluated with repect to varying environmental and economic costs. In general, it is less disruptive environmentally and less costly to construct roads on ridges or in valley bottoms because less cut and fill excavation is required and land is less disturbed. The recommended route has a maximum grade of 7% and a maximum degree of curvature of 5%. These parameters provide a safe design speed of 55 MPH for passenger vehicles. The proposed route has less grade and curvature than the other alternatives. In addition, this route is the shortest and possesses the best sight characteristics at its intersection with the Piceance Creek road.

Preliminary traffic pattern studies estimate that the average daily traffic volume will be enough to require an American Association State Highways and Transportation Officials' Type D road. Geometric design standards for this type of road require two lanes, each 10 feet wide with 6-foot shoulders. The total road width is 32 feet and within the 50-foot guideline set forth in the Lease. However, because the access road to the Tract crosses rough terrain, some additional width in the lateral cut and fill slopes may extend beyond 50 feet in order to construct a safe Type D road. The access road will use approximately 40 to 50 acres. Proper permits will be obtained for off-tract rights-of-way.

The existing Scandard Gulch ridge road will be used for access to the Tract during the early part of Phase I until the new access road can be constructed. In addition to the Type D main access road, other service roads will be constructed on-tract from the mine surface facilities site to the dam site in Sorghum Gulch and between the mine surface facilities site and the primary crushed ore storage pile. These roads will be used for hauling mine shaft rock and crushed shale as well as providing access for construction personnel and equipment to these sites. These haulage roads are expected to be dirt or gravel construction roads during Phase I and to be adequate for haulage trucks. They will require that approximately 4000 linear feet of existing road be improved and will utilize an additional 15 to 25 acres of land.

Additional on-tract service roads will be required in connection with installation of power and communications systems, water supply systems, conveyors and other Tract activity. These roads will be primarily for service and delivery of construction material and will be of graded dirt construction. Existing roads may suffice for some of these activities and will be used to the maximum extent possible. Total acreage used by these additional access roads during Phase I should not exceed 15 to 20 acres.

K. Dams

1. Sorghum Gulch Dam

During Phase I, a dam will be constructed in Sorghum Gulch near the northern boundary of the Tract as shown on Figure II-2. This dam will be of earth-fill construction and will be constructed to a height of approximately 80 feet. During Phase I, this dam will serve as a catchment dam for storm runoff from the mine surface facilities and as a storage dam for ground water produced from the shaft sinking and the mine development phase, with a maximum capacity of approximately 600 acre-feet. See Section V. B., Water Pollution Controls, for additional information on water containment, treatment and disposal. During Phase II, the dam will act as a catchment dam for runoff from the processed shale pile which will be located in Sorghum Gulch. The dam site will require approximately 15 to 25 acres of land for construction.

From an engineering point-of-view, a very narrow section of a canyon that provides for a very large storage volume is the most desirable site for a dam. The primary reasons for locating the dam at the proposed site is to keep it on-tract. A better dam site is located in Sorghum Gulch about 500 feet downstream of the northern boundary line of the Tract. Although the geotechnical and foundation conditions throughout Sorghum Gulch are essentially the same, the off-tract site would be less expensive to build and would provide a much larger storage volume upstream than the on-site location. In addition, placement of the dam off-site would allow additional on-tract area in Sorghum Gulch for processed shale disposal, allowing the overall height of the processed-shale embankment to be reduced. Notwithstanding the potentially better off-tract site, Lessee plans to construct the dam on-tract due to the uncertainties of federal land use policies.

The dam will be designed utilizing standards similar to those delineated by the Bureau of Reclamation text entitled, "Design of Small Dams," and in strict accordance with safety standards of, and with the approval of, the Colorado Division of Water Resources.

During Phase I, the dam will enable productive use of the rock excavated during surface facility and mine shaft construction, and will provide a water containment system for storm runoff from construction activity and a storage system for ground water produced from shaft sinking and development mining activities. During Phase II, the Sorghum Gulch dam will serve as the major catchment area for all runoff water from plant operations or processed shale disposal. The dam or impoundment will be sufficient to withstand the 100-year flood, which will meet all Lease requirements. A spillway will be provided to prevent overtopping the dam. The runoff water stored behind the dam will be utilized to moisturize processed shale. The final engineering design will consider the effects of siltation; either excess storage capacity or dredging will be utilized.

Dam construction procedures involve clearing, grubbing and excavating to prepare the dam site for construction. All top soil (soil with organic material in it to the depth of several feet), will be removed from the entire dam section. Figure II-13 illustrates the design of an earth-filled dam of the type to be constructed in Sorghum Gulch. At the center of the dam, a cut-off trench will be excavated through the alluvial material across the valley into sound bedrock. In Sorghum Gulch, this alluvial material appears to be only about 20 feet thick. This cut-off trench would run part way up the sides of the canyon. Grout holes will be drilled and the foundation area will be grouted as necessary to seal off the rock strata beneath the dam. The cut-off trench will be backfilled with low-permeability core material. As the core is raised in several lifts, filter material is laid in on either side of the core and a random rock and earth fill is constructed to the same height as the core. This process is repeated until the dam is completed. Random fill means that various types of material can be used and that segregation of different types and sizes of material is not as stringent as in the core and other critical locations. Most of the materials for the dam, except the core material, will come from the shaft-sinking excavation and from other disturbed areas, in which case there will be limited need to develop borrow pits to provide materials

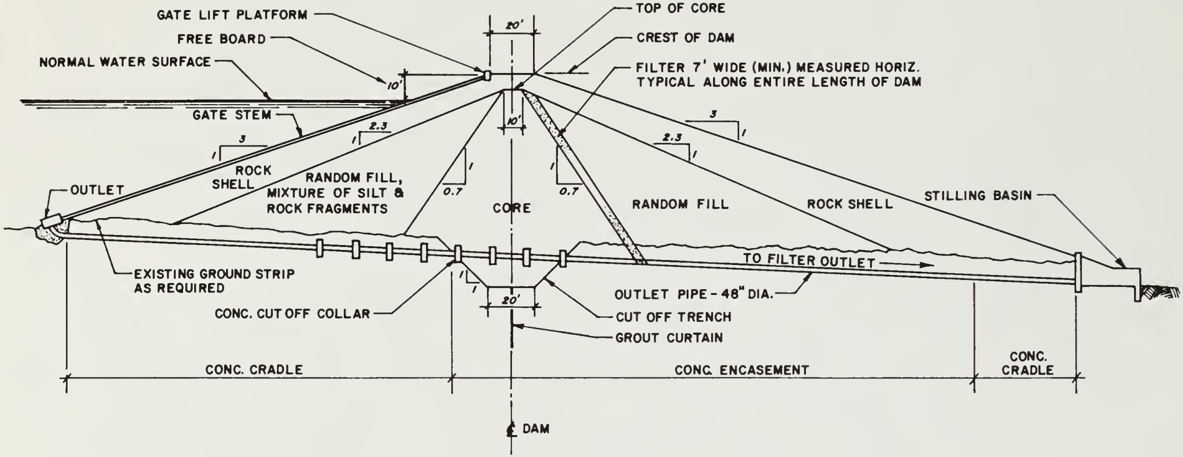


Figure II–13 TYPICAL SECTION,
EARTH AND ROCK FILL DAM

for the dam. A construction materials survey will be conducted to determine suitability of materials available on-tract for dam construction.

If additional material is required, it can be obtained from road construction activity, or if road excavation material is insufficient or unsuitable, from a borrow pit on or off-tract. Proper permits will be obtained as necessary. The most probable borrow pit location is in the impoundment area of the dam, below the water level, thus increasing storage capacity of the dam by the volume of fill extracted.

2. Stockpile Runoff Catchment Dam

A small catchment and gathering dam will be constructed below the coarse-ore stockpile in Cottonwood Gulch to collect all runoff water. The water from this impoundment will be used for construction water supply or other uses as described above in connection with the Sorghum Gulch dam. Water treatment is discussed in Section II. L.

3. Other Dams

No other dams are contemplated during Phase I. For discussion of dams that may be constructed during Phase II, see Section III.

L. Coarse-ore Conveyor and Stockpile

After completion of shaft sinking, development mining will commence. Development mining is expected to continue during the last two years of Phase I and possibly into the first part of Phase II. Shale which is mined during development mining will be crushed in a primary crusher located underground; the crushed shale will than be transported to the surface and stored in a pile which will be located in the area and configuration shown in Figure II-2. The pile will grow as development mining continues and will eventually reach a size of approximately 35 acres. During Phase I, construction of the coarse-ore stockpile area will begin by cutting a bench section into the slope. A V-shaped trough will be excavated below the bench to provide for crushed-shale storage. At the bottom of the trough, a re-claim tunnel will be constructed. In Phase II, an ore stacker which operates on a rail system will traverse the length of the pile along the bench cut. The re-claim tunnel will be used to supply primary crushed shale to a conveyor belt which will transport it to the secondary crusher located at the retorting and upgrading plant site. The conveyor system which will haul coarse ore from the mine shaft to the coarse-ore storage pile will be engineered and constructed during the shaft-sinking portion of Phase I. This conveyor will be used during the remainder of Phase I and during Phase II to carry coarse ore to the coarse-ore storage pile. If the conveyor is not completed when initial development mining begins, trucks will be used to haul the ore until the conveyor is constructed. An alternative timing schedule for the coarse-ore conveyor would delay construction until the beginning of Phase II. However, Lessee's plan is to construct the conveyor system in Phase I. A drainage control system will be required to route water around the pile. In addition, a catchment dam will be constructed below the pile to catch runoff water as described in Section II. J. 2.

The location selected for the coarse-ore stockpile is preliminary and cannot be finalized until final engineering design of the pyrolysis structure is complete and the slope limitations of conveyors between the coarse-ore stockpile, the secondary crusher, and the pyrolysis units can be defined.

M. Mine Shaft Dewatering, Water Treatment and Disposal System

1. Mine Shaft Dewatering

During shaft sinking and development mining conducted as part of Phase I operations, it will be necessary to dewater the underground workings. Data available to date indicates that significant inflows will be encountered below a depth of approximately 400 feet. The current best estimate for inflow of water to the mine shafts indicates a peak flow of 3.7 CFS and an average annual peak flow of 3.4 CFS (Figure II-14). Although the accuracy of the computer calculated result is not particularly high ($\pm$ 42%), it is believed that the parameters and results are adequate for the hydrologic design of the shaft and shaft-sinking method. Pilot core holes drilled on the center lines of the shafts will provide more specific quantitative data prior to shaft construction. Inflow into the development mine is expected to increase very slowly, if at all, above peak values encountered during shaft sinking.

Computation of water inflow rates does not contemplate the use of impermeable shaft liners, grouting, or using advance dewatering wells. Use of any of these techniques would tend to reduce inflow. Moreover, it has been estimated that about 0.8 CFS will be used to satisfy construction requirements for dust control, compaction, concrete, etc. When all factors are considered, it is believed that a continuous year-round disposal capacity of 2.6 CFS will be needed.

Chemical quality of the inflow water can be estimated from the analysis of samples taken from the upper aquifer (above the mine zone) and the lower aquifer (below the mine zone) during the aquifer pump tests. Table II-3 represents the concentrations of major constituents found after 23 days of pumping during the upper aquifer pump test, ending December 23, 1974. This is the best estimate for composite water quality expected as inflow to the mine shafts. Water flow into the development mine could come from both above and below the mining zone. Table II-4 is a water quality analysis from the lower aquifer pump test on February 16, 1975. It is not possible at this time to estimate the ratio of water inflow from above the development mine to that from

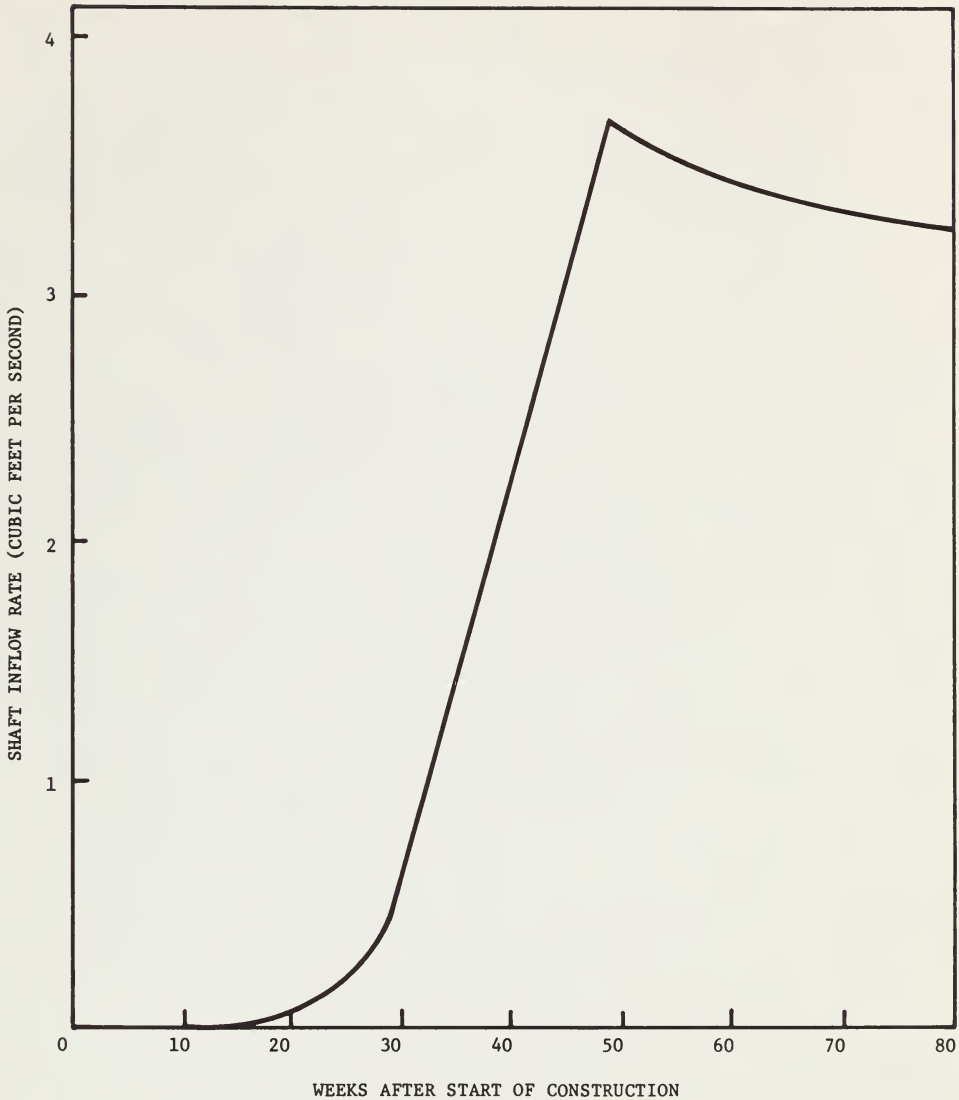


Figure II–14 PHASE I MINE SHAFTS WATER INFLOW ESTIMATE

Table II–3 WATER QUALITY FROM UPPER AQUIFER PUMP TEST

Constituent	Concentration mg/liter
Bicarbonate	570
Boron	1.5
Calcium	16
Carbonate	–
Chloride	7
Fluoride	18
Magnesium	10
Sodium	200
Sulfate	4
Total Dissolved Solids	560

Table II–4 WATER QUALITY FROM LOWER AQUIFER PUMP TEST

Constituent	Concentration mg/liter
Bicarbonate	755
Boron	3
Calcium	4
Carbonate	11
Chloride	5
Fluoride	19
Magnesium	3
Sodium	310
Sulfate	12
Total Dissolved Solids	750

below. For the purpose of discussion in this DDP, an average of Tables II-3 and II-4 will be assumed for water inflow to the development mine.

As can be seen on the tables, the water from the mine and shaft dewatering operations will be of generally good quality. The total dissolved solids (TDS) content of this produced water will be less than Piceance Creek (900 mg/l below the Tract). However, the produced water will contain a high concentration of fluoride, which will necessitate special handling and treatment techniques.

2. Water Treatment and Disposal System

Four different techniques will be relied upon for disposal of excess mine water during Phase I. These are: 1) evapotranspiration by sprinkler irrigation in the portion of Sorghum Gulch designated as the ultimate location of the processed-shale pile; 2) reinjection into the lower portion of the upper aquifer system; 3) defluoridation by adsorption on activated alumina with the effluent discharged to Piceance Creek; and 4) use in construction activities. A necessary component of the complete system is the water storage reservoir at the foot of Sorghum Gulch described in Section II. J.

Evapotranspiration. It is estimated that approximately 600 acres within the projected processed-shale pile area in Sorghum Gulch can be utilized as a sprinkler irrigation area. Sprinkler irrigation, a new technique for disposal of effluent from municipal sewage treatment plants, is currently receiving widespread consideration. Installation of fixed sprinklers on 600 acres with an automated control system would give a yearly average disposal capacity of 1.3 CFS. At this rate, all water applied would be evaporated, and no downward percolation into the soil would occur.

Because no net evapotranspiration is achievable from October through March (Figure II-15), it will be necessary to annually store the 500 acre-feet of water produced during this period. A dam will be built in Sorghum Gulch for this purpose. In addition to accommodating 500 acre-feet of water from the dewatering operation, the total storage capacity must be large enough to also contain the 100-year design flood. Figure II-16 depicts the 100-year storm for the Sorghum Gulch drainage area. The 24-hour value for a 100-year storm is 2.8 inches. Figure II-17 gives the runoff from a 6-hour value of the 100-year storm as computed by Meiman in the Thorne study entitled "An Environmental Reconnaissance of the Piceance Basin" (1973). Figure II-17 is based on an antecedent moisture condition #II and shows a total runoff of about 40 acre-feet from the entire Sorghum Gulch drainage. Thus the total reservoir capacity must be about 600 acre-feet. From Figure II-18, it is seen that approximately 30 acres are required for reservoir area, with a maximum depth of 70 feet. It probably would not be economical to build this dam only for use with the sprinkler disposal system.

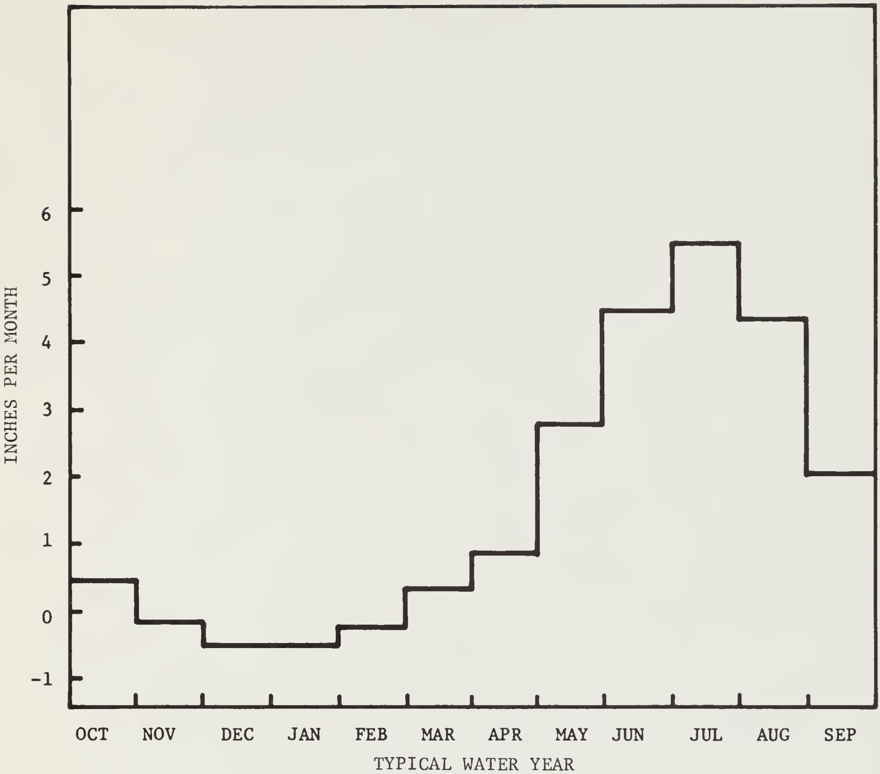


Figure II—15 POTENTIAL EVAPOTRANSPIRATION RATES FOR TRACT C-b

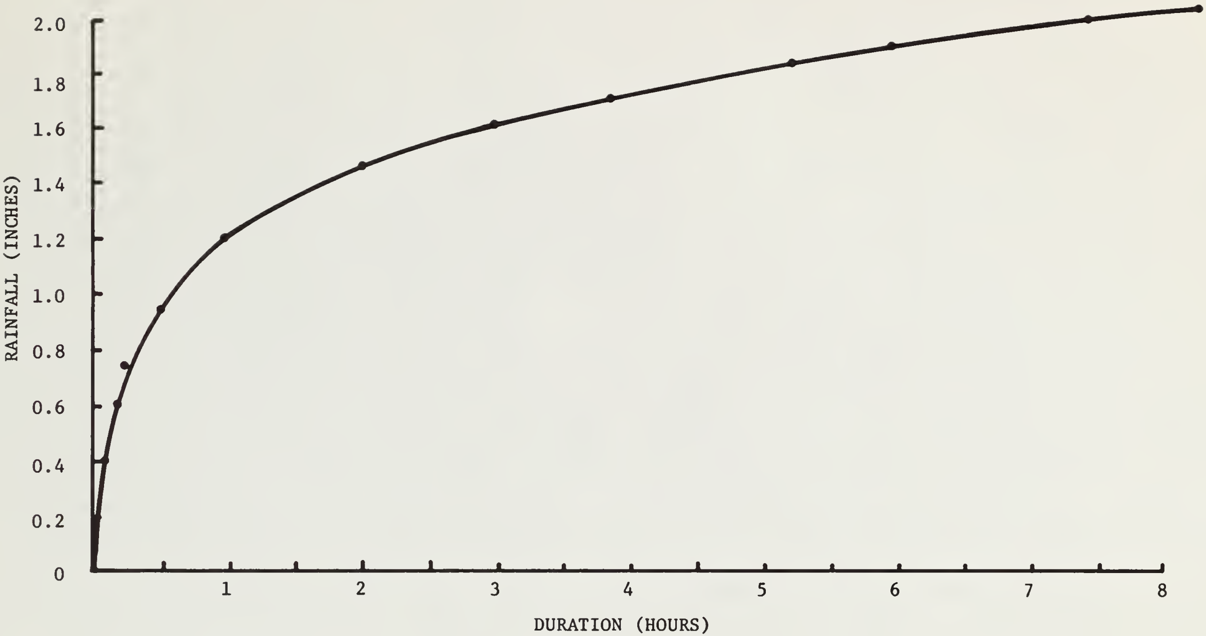


Figure II–16 SORGHUM GULCH – I PERCENT PROBABILITY STORM, 100-YEAR RECURRENCE (Meiman 1973)

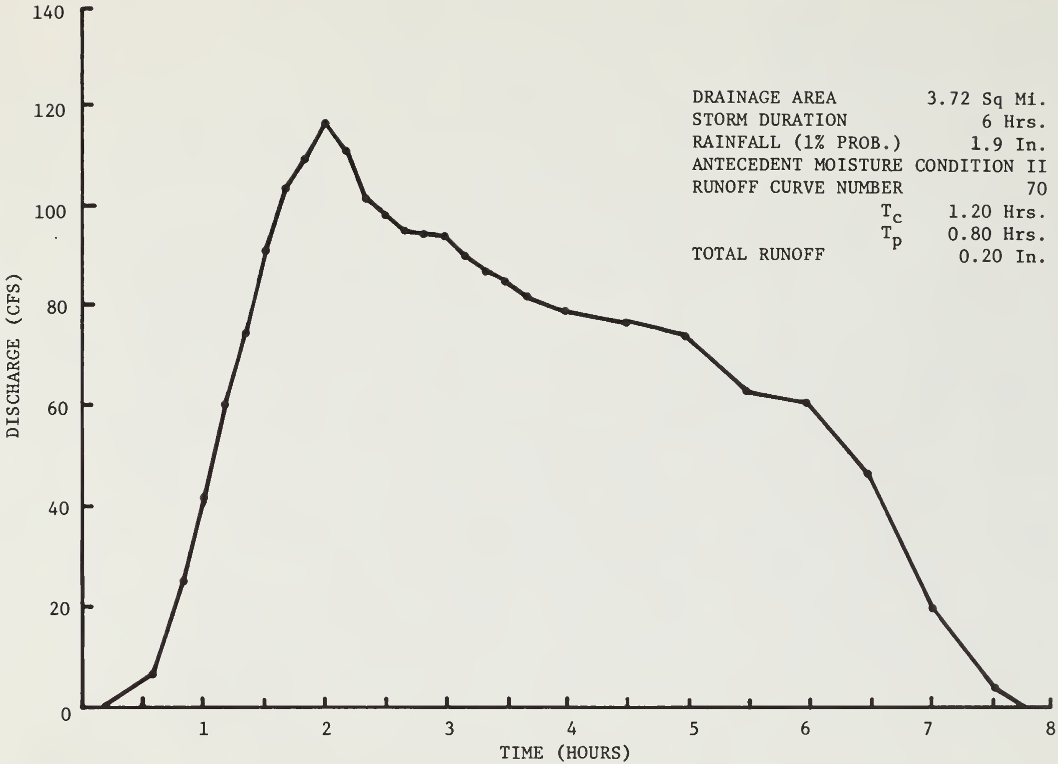


Figure II—17 SORGHUM GULCH FLOOD HYDROGRAPH FOR THE 1% PROBABILITY EVENT BY TRIANGULAR HYDROGRAPH (Meiman 1973)

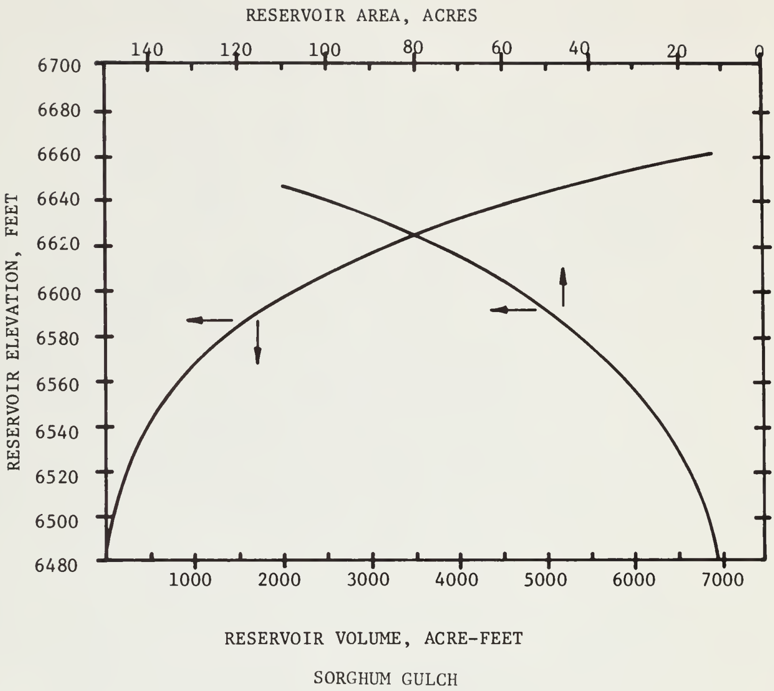


Figure II–18 RESERVOIR AREA – CAPACITY CURVES FOR SORGHUM GULCH

However, the dam and reservoir can serve a dual purpose during Phase II. It is expected that surface water will have to be imported to satisfy most of the plant operating requirements. The Sorghum Gulch reservoir can then be used to provide emergency and surge storage for the surface water supply. Six hundred acre-feet will be in excess of a 30-day supply for the plant. Alternatively, in case of a prolonged plant shutdown which would necessitate disposal of the mine inflow water, the reservoir could be drained of good quality water and used to accumulate mine water for a period of several months.

Continued use of evapotranspiration by sprinkler irrigation will result in the slow accumulation of fluoride in the upper layers of soil. The EPA is recommending a limit of 15 PPM fluoride in irrigation water if used for no more than 20 years. The case at hand, involving 20 PPM fluoride for 5 to 7 years, will not result in a higher buildup of fluoride than recommended by the EPA. Hence, subsequent reuse of this soil for revegetation and rehabilitation purposes should not be adversely affected.

Reinjection. The capacity of the sprinkler system will be approximately 1.3 CFS on a yearly average. As larger flows are encountered, a reinjection well or wells will be used to provide any additional disposal capacity required. One reason for switching to reinjection after a certain water production rate is exceeded is that the capacity of the sprinkler system cannot be expanded without also increasing the size of the retention dam. This is not economically practical. If avoidable, building a new dam solely for this purpose would be economically and environmentally undesirable.

On the basis of preliminary calculations, a reinjection well will have a design capacity of 1 CFS. The most desirable location for such a well is downslope on the ground water hydraulic gradient from the mine shaft, and as far from the shaft as is practical. This means that the disposal well would be located north of the mine shaft and near the northern Tract boundary.

Investigations of possible subsurface disposal alternatives have led to the conclusion that inflow water produced during Phase I should be reinjected in the upper aquifer system, essentially to the same zone from which it will be produced. The economics of reinjection depend mostly on the injection rate which can be maintained. Preliminary calculations indicate that 1 CFS per injection well can be handled easily without excessive injection pressures. As larger disposal capacities are needed, the cost will go up in increments as each well is added. Injection costs start at a higher value than minimum defluoridation costs, but increase at a much lower rate.

Since no surface effects would be perceivable, reinjection is not only the most economical solution at high flow rates, but also environmentally attractive.

Defluoridation. As an alternative to reinjection, a small ion exchange defluoridation plant with a treatment capacity of 1.3 CFS will be built as part of the mine surface support facilities. Figure II-19 illustrates the schematics of an ion exchange defluoridation unit. The chief component of this plant is a 15,000-gallon tank containing activated alumina. Water will be pumped directly from the mine shaft to the defluoridation plant. Any flow in excess of the defluoridation plant capacity will be diverted via pipeline or stabilized channel to the Sorghum Gulch reservoir.

Adsorption on activated alumina represents the best available technology for removal of fluoride from waste waters. The effluent from this plant should meet all proposed EPA limits for fluoride in drinking water. Flow from the plant outlet will be directed to Sorghum Gulch below the dam. At this point, a mixing station mav be desirable so that following alumina regeneration cycles, when fluoride in the effluent is at a minimum, some reservoir water can be diluted by the plant output but still meet discharge standards. The effluent will be continuously monitored for fluoride levels using specific ion electrodes.

Other Alternatives. Other possible methods for handling excess Phase I water which are not contemplated for use under expected conditions but which will be examined if the need arises are: 1) storage for later use; 2) solar evaporation from ponds; and 3) surface discharge. These alternatives are discussed below.

Storage. Since it is expected that the ultimate water consumption rate will exceed the mine water inflow rate, one possible alternative to the preferred disposal program would be to store the produced water in a surface reservoir until such time as it could be used. A number of possible dam sites were studied on or in the vicinity of the Tract, of which only two appear to be feasible. These sites are located in West Fork Stewart Gulch and Scandard Gulch. The potential storage capacity at each site is shown in Figure II-20. A flow of 2.6 CFS is equivalent to 2000 acre-feet per year. Considering likely evaporation losses, a large dam in either Scandard or Stewart Gulches would store the expected outflow for the six or seven years necessary until commercial operations begin.

Storage of mine water in a reservoir for a period of years would result in increased concentration of fluoride due to evaporation of water from the reservoir surface. For either the Scandard Gulch or West Fork Stewart Gulch site, the relationship of surface area to reservoir volume is approximately the same. Evaporation could be on the order of one-tenth of the ultimate reservoir volume per year. The economics of constructing a 200-foot high dam in West Fork Stewart Gulch to create a 12,000 acre-foot reservoir are estimated to be inferior to those of defluoridation or reinjection. However, if the dam could be wholly or partly justified on some other basis, such as for storing

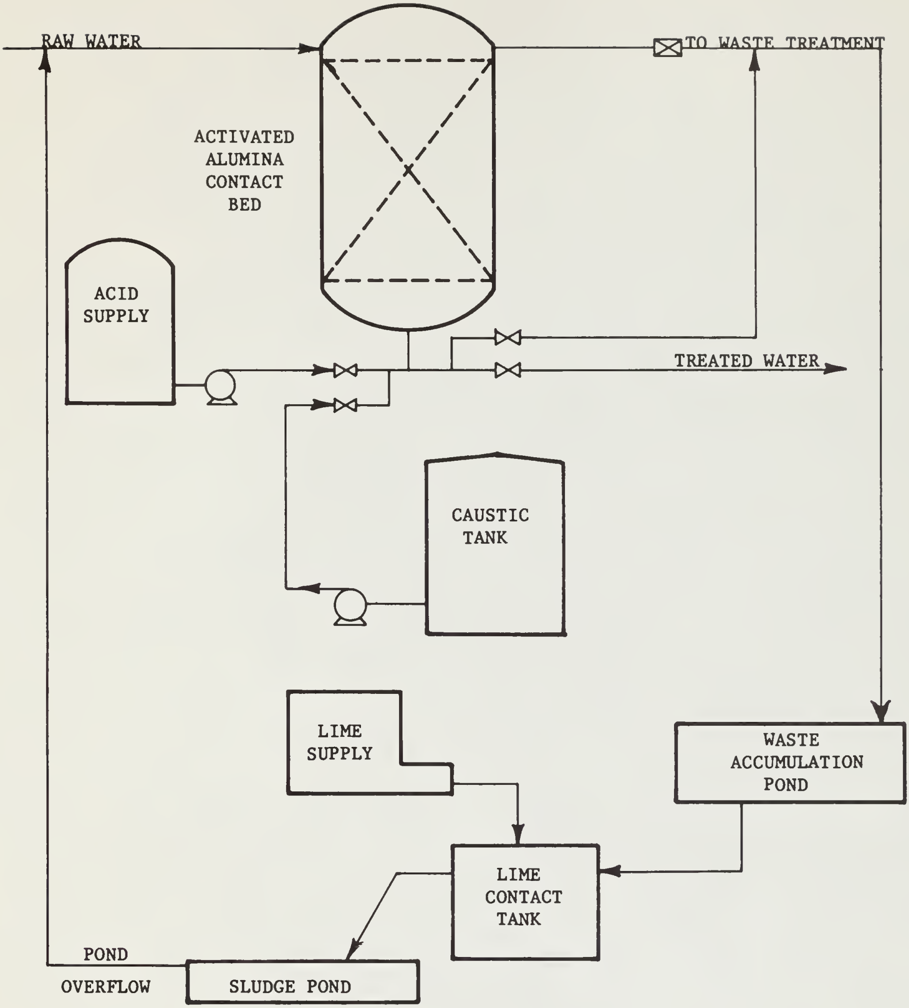
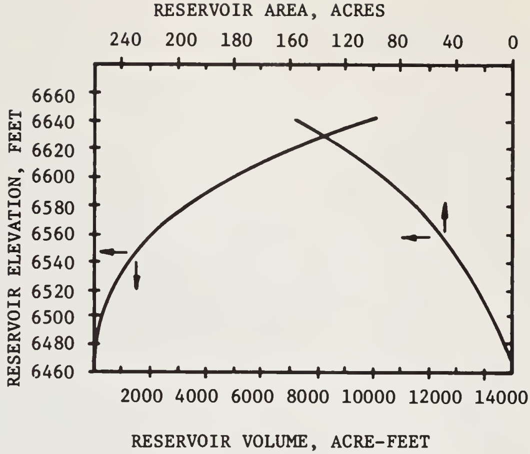
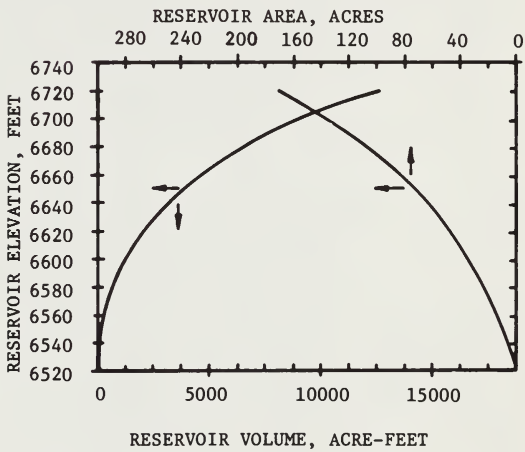


Figure II–19 ION EXCHANGE DEFLUORIDATION PLANT



SCANDARD GULCH



WEST FORK STEWART GULCH

Figure II–20 RESERVOIR AREA – CAPACITY CURVES FOR SCANDARD GULCH AND WEST FORK STEWART GULCH imported water during plant operation or providing surge capacity for mine water during plant shut-downs, then the economics might become favorable.

Solar Evaporation. Disposal of saline water is often accomplished through solar evaporation from ponds. The altitude and average temperature on the Tract do not result in attractive average evaporation rates. The total solar and sky radiation on a horizontal surface, converted to inches of evaporation equivalent as measured at Grand Junction, is approximately 112 inches per year. When corrected for the effect of ambient temperature, however, the actual pan evaporation rates are considerably less. An estimate of 60 inches per year has been obtained from several sources. If this value is used for an order-of-magnitude calculation and corrected only by subtracting 12 inches of annual precipitation, it can be seen that a minimum of 520 acres of evaporation ponds would be required to handle 2.6 CFS of flow.

The most obvious drawback to using surface evaporation is the large land area which must be devoted to evaporation ponds. Only the more level portions of the Tract would be usable for ponds. If water inflow to the development mine is appreciably in excess of that expected for peak shaft inflows, then the pond area requirements become excessive.

The high fluoride levels reached in an evaporation pond may make the water toxic to some forms of life. It might therefore be necessary to install fencing to prevent all contact with the water. Leaching from the ponds could result in high fluoride levels in ground water which might eventually reach the surface through spring flows. A detailed hydrologic analysis would be required to evaluate this problem. An alternative would be to line all ponds with impervious material.

Surface Discharge. Surface discharge of a portion of the produced water is a viable disposal alternative. One of the major drawbacks is the absence of fixed discharge water quality standards. The two parameters of major concern are total dissolved solids and fluoride ion concentration. The EPA has proposed establishing a fluoride limit of 2 mg/l for drinking water. However, discharge into Piceance Creek would not jeopardize any known drinking supplies. Though TDS may eventually be regulated with respect to the effect on salinity in the lower Colorado Basin, specific control measures have not yet been formulated. The overall goal of the salinity control program is to avoid increasing the TDS measured at Hoover Dam over the 1972 level of 723 mg/l.

Figure II-21 presents a hydrograph of Piceance Creek (USGS Professional Paper 908) below the Tract. A continuous discharge of 2.6 CFS would amount to 15% of the mean yearly flow in Piceance Creek at this location.

The concentration of total dissolved solids in Piceance Creek below the Tract is about 900 mg/l. Thus a direct discharge of water pumped

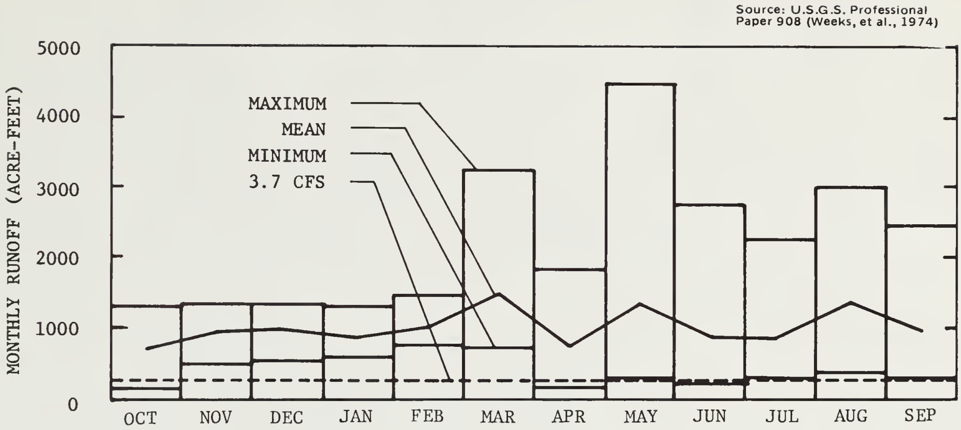


Figure II–21 HYDROGRAPH FOR PICEANCE CREEK BELOW THE TRACT from the mine shaft (Table II-3) would not result in a degradation of water quality in Piceance Creek as far as TDS is concerned. An average of Tables II-3 and II-4, representing inflow to the development mine, would also be an acceptable level to assure non-degradation of Piceance Creek.

The expected maximum concentration of fluoride in the shaft inflow water is approximately 20 PPM. Figure II-22 shows the effect of discharging the single-point peak flow of 3.7 CFS of untreated water directly to Piceance Creek, based on the mean flows given in Figure II-21. If, instead of mean values, the minimum flow values from Figure II-21 are used, the effect is much worse, as seen in Figure II-23. It should be noted that a complete year with water flows near the minimum value in every month is extremely unlikely. In any case it is apparent that direct discharge of all untreated mine water would produce excessive fluoride concentrations in Piceance Creek. However, once standards are established, it might be possible to discharge a portion of the produced water into Piceance Creek during periods of high flow.

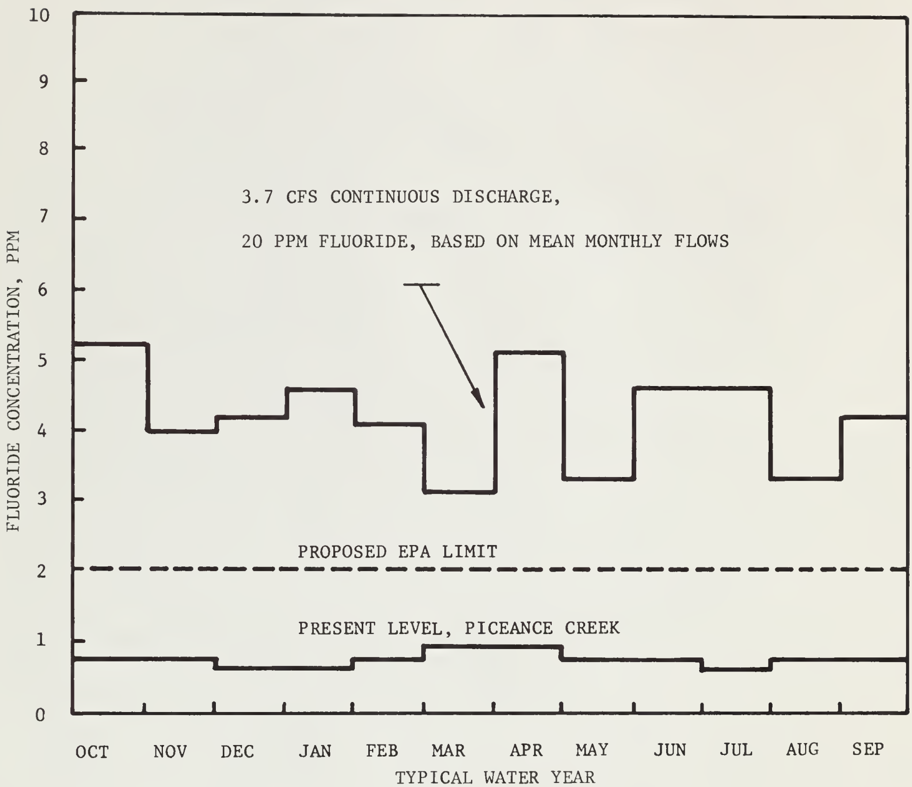


Figure II–22 MAXIMUM FLUORIDE LEVELS IN PICEANCE CREEK RESULTING FROM DIRECT DISCHARGE OF MINE WATER (MEAN CREEK FLOW CURVE)

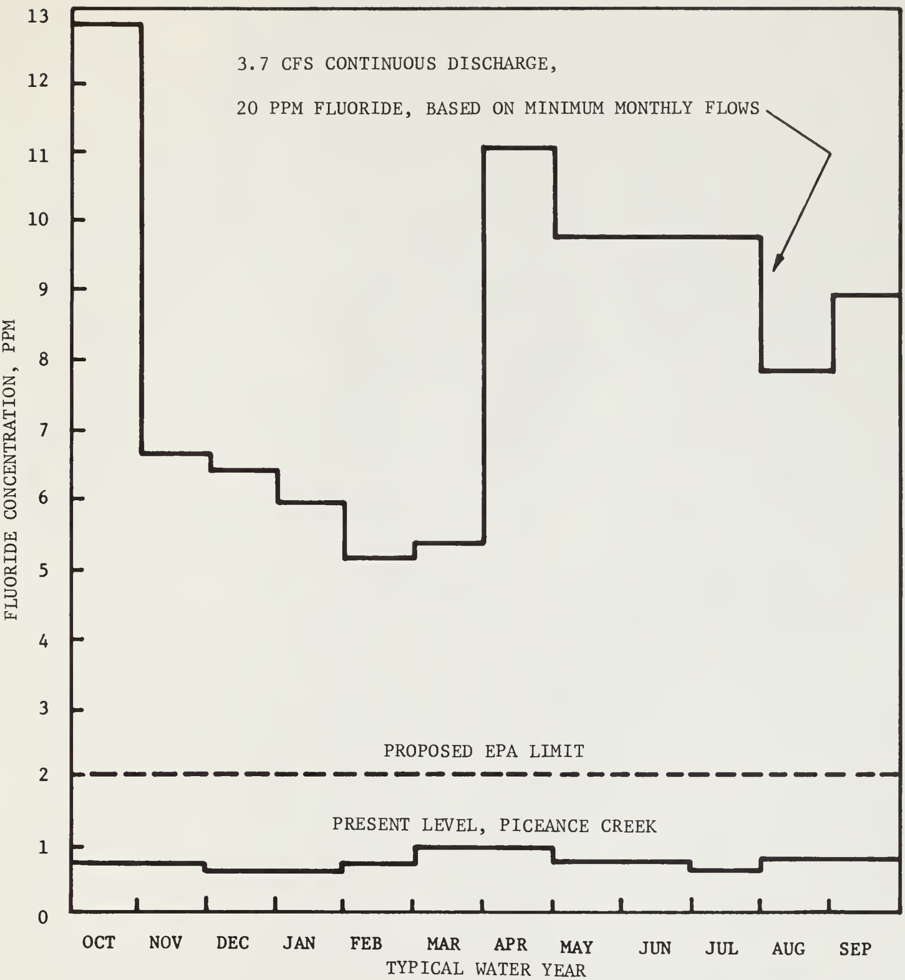


Figure II–23 MAXIMUM FLUORIDE LEVELS IN PICEANCE CREEK RESULTING FROM DIRECT DISCHARGE OF MINE WATER (MINIMUM CREEK FLOW CURVE)

III Phase III - Plant Construction

III Phase II - Plant Construction

III. PHASE II - PLANT CONSTRUCTION

Phase II refers to the time period commencing with the initiation of construction of commercial plant facilities (approximately five years after the DDP is approved) and ending with plant start-up and the beginning of commercial shale oil production activity. Phase II is expected to last approximately four years.

A. Introduction and Summary

Engineering for plant construction will begin in Phase I, about two years prior to the commencement of Phase II, in order to schedule certain critical and long-delivery equipment associated with commercial construction. Construction will begin as soon as practicable after engineering in order to minimize delay in plant start-up.

The following materials summarize Phase II activity:

Phase II Development Schedule. Figure III-1 is a schedule of activities to be carried out in Phase II.

Phase II Project Plot Plan. Figure III-2 presents a plot plan showing all major facilities which will be constructed during Phase II, as well as those previously constructed in Phase I.

Phase II Surface Disturbance. Table III-1 lists the surface acreage which will be disturbed during Phase II as well as that previously disturbed in Phase I, by year, together with the cumulative total acreage disturbed.

Phase II Manpower Estimate. Figure III-3 shows the estimated Phase II manpower for construction activity.

The remainder of this section describes the schedule and manpower requirements, as well as detailed descriptions of the specific construction activities which will occur in Phase II.

B. Schedule and Manpower

Because of the multitude of construction activities, Phase II will be the time of maximum activity and manpower requirements. Figure III-1 shows the activity schedule and Figure III-3 represents the estimated manpower for Phase II. Estimates of manpower and scheduling have been based upon preliminary engineering and planning work, and are thus ultimately dependent upon many factors not presently determinable.

A skills breakdown for the expected manpower has not been presented in Figure III-3 because detailed engineering and planning has not been completed. However, an estimate of total craft labor for Phase II has been prepared (Table III-2). Table III-2 includes crafts only and does not consider the contractor's or Operator's staff and staff-support personnel requirements, nor the development mine force. Based on present knowledge, total man-months for each craft were estimated. The sum of these estimates for Phase II activities was 65,680 man-months. This approach yields only an approximate total skills breakdown and does not yield a representation of the timing of required crafts.

C. On-tract Surface Facilities

All major on-tract surface facilities for plant operations will be constructed during Phase II. These facilities will include:

- roads
- commercial mine surface facilities
- retorting and upgrading units
- crushing, conveying and processed-shale disposal systems
- dams
- support facilities

The selection of specific siting areas for the surface facilities on the Tract has been, and will be, based on both environmental and economic considerations. Both environmental and economic costs are generally directly related to the amount of land area disturbed; thus a site which minimizes land disturbance is favorable for both environmental and economic reasons.

The plant site is situated so that runoff from the various process areas can easily be controlled and concentrated in Sorghum Gulch. The portion of Sorghum Gulch on-tract will be totally disturbed by processed-shale disposal, so efforts will be made to concentrate disturbances in that watershed in order to minimize impact on other watersheds.

The central location of facilities is of significant economic benefit. Construction costs of common facilities greatly increase with distance between the units. Examples of this would be the longer conveyors, additional road lengths and minimization of joint-use facilities such as guard houses, change houses and maintenance facilities that would result if facilities were not centrally located.

Prepared with these principles in mind, the remainder of this section describes the on-tract facilities in more detail.

1. Roads

In order to transport men, equipment and material to the Tract and to areas of construction of all facilities, several roads in addition to those constructed during Phase I will be completed in the early stages of Phase II. These roads include access routes to mine ventilation

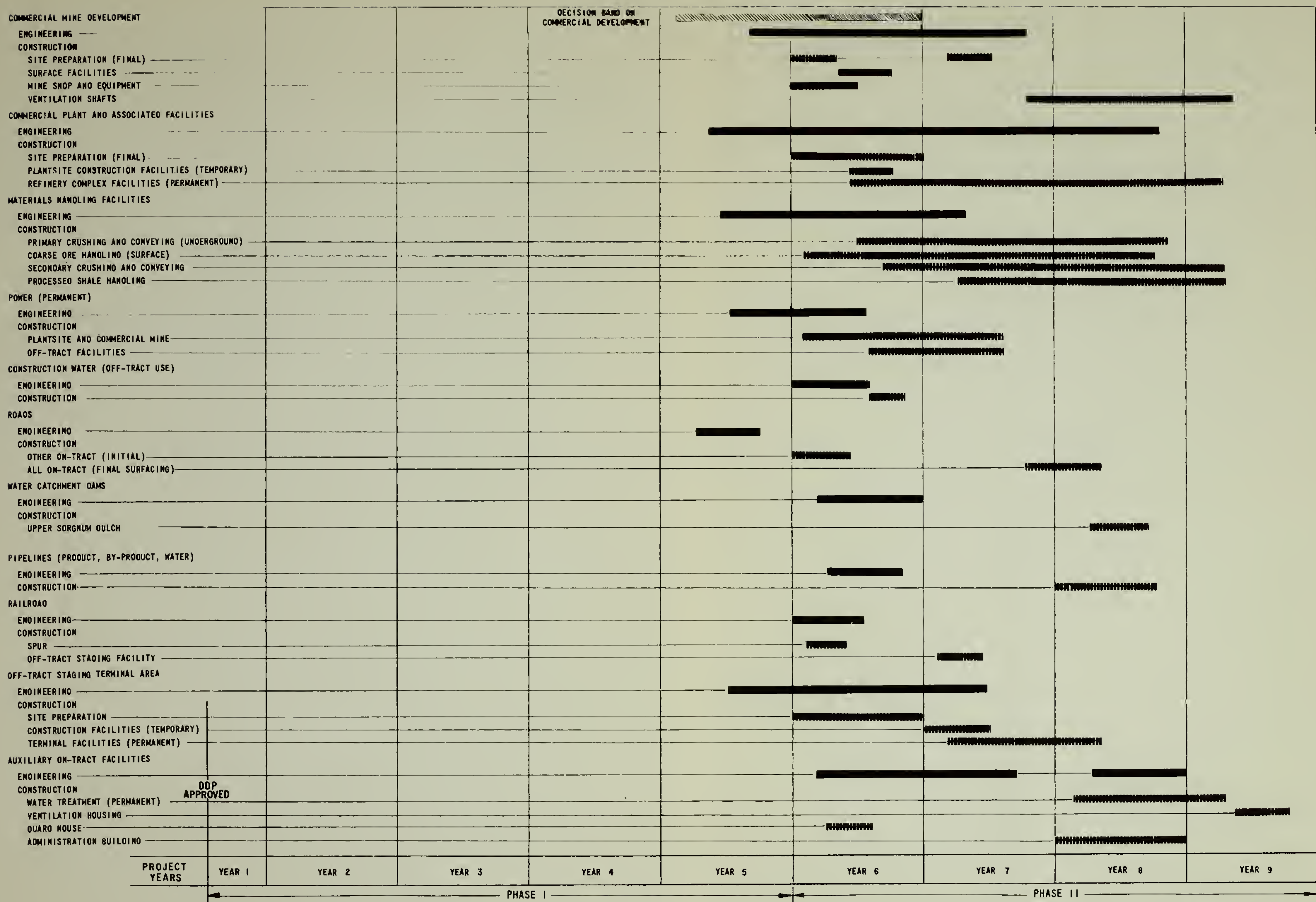
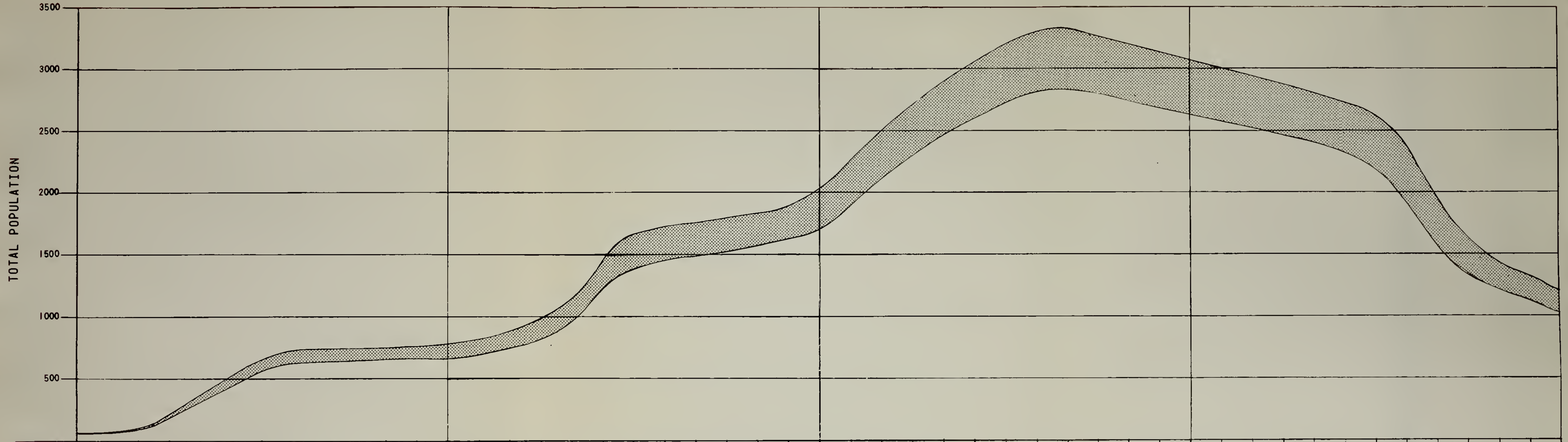


Figure III–1 PHASE II DEVELOPMENT SCHEDULE

Figure III–2 PHASE II PROJECT PLOT PLAN



MANPOWER	PROJECT MONTHS	1	2	3	4	5	6	7	8	9	10	11	12
		YEAR 6 AFTER OOP APPROVAL											
	MAXIMUM	70	100	150	300	450	600	700	740	750	750	760	775
	BEST ESTIMATE	65	95	140	275	410	550	650	690	690	700	710	720
	MINIMUM	60	85	125	250	375	500	600	630	640	650	660	660

MANPOWER	PROJECT MONTHS	1	2	3	4	5	6	7	8	9	10	11	12
		YEAR 7 AFTER OOP APPROVAL											
	MAXIMUM	800	850	925	1050	1275	1600	1700	1750	1775	1825	1850	1950
	BEST ESTIMATE	740	790	850	960	1175	1460	1560	1610	1640	1690	1725	1800
	MINIMUM	675	725	775	875	1075	1325	1425	1475	1500	1550	1600	1650

MANPOWER	PROJECT MONTHS	1	2	3	4	5	6	7	8	9	10	11	12
		YEAR 8 AFTER DDP APPROVAL											
	MAXIMUM	2125	2375	2600	2800	2975	3125	3250	3325	3300	3225	3160	3100
	BEST ESTIMATE	1950	2190	2400	2590	2750	2890	3010	3075	3060	3000	2940	2875
	MINIMUM	1775	2000	2200	2375	2525	2650	2775	2825	2825	2775	2710	2650

MANPOWER	PROJECT MONTHS	1	2	3	4	5	6	7	8	9	10	11	12
		YEAR 9 AFTER ODP APPROVAL											
	MAXIMUM	3040	2975	2910	2850	2775	2700	2550	2200	1800	1525	1375	1275
	BEST ESTIMATE	2820	2760	2705	2650	2575	2490	2325	1990	1625	1400	1270	1175
	MINIMUM	2600	2550	2500	2440	2375	2275	2100	1775	1450	1275	1165	1075

Figure III–3 PHASE II MANPOWER ESTIMATE

Table III-1 PHASE I AND II PROPOSED SURFACE DISTURBANCE BY YEAR
AREA DISTURBED (ACRES)

DDP APPROVAL

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to end of operation	Total by Activity
PHASE I												
Mine Surface Facilities		25-35										25-35
Coarse Ore Conveyor		5-10										5-10
Coarse Ore Stockpile (Initial)		35-40										35-40
Road Construction (New)												
-Primary Tract Access		40-50										40-50
-Dam Access		10-15										10-15
-Primary Coarse Ore Conveying/ Stockpiling		5-10										5-10
Dam Sites (Sorghum & Cottonwood Gulches)		15-25										15-25
Construction Water		5-10										5-10
Reservoir (Sorghum Gulch)		5-10	10-15									15-25
PHASE II												
Truck Maintenance Facility						10-15						10-15
Plant Site						150-200						150-200
Processed Shale Handling System							15-20					15-20
Power R-O-W						5-15						5-15
Pipeline Corridor R-O-W								10-20				10-20
Road Construction (New)												
-Ventilation Housing Access						15-20						15-20
-Secondary Coarse Ore Stockpile						2-5						2-5
-Water Catchment Dam							10-15					10-15
Auxiliary Buildings								25-30		3-5		28-35
Coarse Ore Stockpile (Temporary)								25 35	15-20			40-55
Dam Site (Scandard Gulch)*							25-40					25-40
Reservoir (Scandard Gulch)*								40-70	50-100			90-170
TOTAL BY YEAR		145-205	10-15			182-255	50-75	100-155	65-120	3-5		555-830

*Dam and reservoir constructed only if additional mine dewatering storage is needed.

Table III–2 PHASE II ESTIMATE OF CRAFT LABOR

(Journeymen Class in Rio Blanco County, Colorado)

Crafts	Man Hour Distribution (%)	Total Craft Man Months
Asbestos	8	5,254
Boilermaker	5	3,284
Bricklayer	1	657
Carpenter	10	6,568
Masons	2	1,314
Electrician	10	6,568
Ironworker	9	5,911
Laborer	18	11,822
Millwright	4	2,627
Operator	5	3,284
Painter	1	657
Pipefitter	20	13,136
Sheetmetal	4	2,627
Teamster	3	1,971
Totals	100	65,680

shaft locations, the processed-shale disposal site in Sorghum Gulch, and along service corridors for power lines, telecommunication systems, by-product lines, water lines and the shale oil product line. In addition, some roads constructed during Phase I may require upgrading. If the dam in Scandard Gulch is required, an access road will be constructed.

2. Commercial Mine Surface Facilities

One of the initial activities carried out under Phase II will be the expansion of the mine surface facilities to encompass commercial needs. This will result in the utilization of the full 25 acres of land cleared and leveled in Phase I. Construction of the commercial mine surface facilities will include an enlarged change house, material storage yard and offices.

3. Retorting and Upgrading Units

Beginning at approximately the same time as the commercial mine site work, soil testing and preparation of the retorting and upgrading plant site will be initiated and completed. The balanced cut and fill technique will be used to the extent possible to prepare the plant site. The plant site will utilize approximately 150 to 200 acres of land, as shown in Table III-1.

During early construction, the plant site will be used as a staging area for construction materials to minimize additional land disturbance for this activity. It will be necessary to initially construct some temporary facilities on the plant site to support construction activities. Later, these temporary structures will be replaced with permanent buildings.

Almost immediately after site clearance, construction of the retorting, upgrading and related facilities will commence. During the following three-year period, foundations will be poured, underground systems installed, structural steel placed, pipelines routed, and equipment installed and tested. Once all equipment is in place and demonstrated to be operational, plant start-up will occur. Figure III-4 is a preliminary plot plan showing the location and size of various facilities to be constructed at the plant site during Phase II.

4. Crushing, Conveying and Processed-shale Disposal Systems

The construction of the underground commercial primary crushers and the underground conveyors from the primary crushers to the production shaft will occur in Phase II.

Concurrently, the secondary crushers and the raw shale conveying system from the coarse-ore stockpile through the secondary crushers and to the retort unit will be constructed.

The processed-shale handling system will be developed simultaneously with the retorting, upgrading and other associated facilities. This system will include several conveyors and a processed-shale truck load-out station. During commercial operations, trucks will transport processed shale from the load-out station to Sorghum Gulch for disposal.

5. Dams

The catchment dam below the processed-shale pile will have been constructed in Phase I as previously discussed (Section II). Before any processed shale is deposited in Sorghum Gulch, a permanent catchment dam will be constructed at the upper end of the disposal area near the southern boundary of the Tract (Figure III-2). Maximum runoff from the area of Sorghum Gulch above the south property line, using the 100-year flood conditions, will not result in more than 20 acre-feet of water. This 20-acre feet of water represents the 100-year flood prediction for the upper half of Sorghum Gulch. The entire Sorghum Gulch flood was predicted as 40 acre-feet (Section II. L. 2.).

During construction of the pile, a progressing series of temporary retention dams will be built directly upstream from the processed shale pile to catch and store runoff from above the pile and below the permanent dam. This water will be used in construction and operations activities. The drainage above the pile and between the temporary and permanent dams covers a very limited watershed, and thus the temporary dam will be a small earthen structure which will progressively be moved upstream as the pile proceeds to reach its full areal extent.

Upon completion of development mining in Phase I, commercial mine water production will be estimated. Present expectations are that mine water storage will be provided by the Sorghum Gulch dam as set forth in Section II. However, if required, additional storage could be provided by locating the Sorghum Gulch dam off-tract or by building an additional dam in either Scandard Gulch or West Fork Stewart Gulch (Figure III-5).

If the Sorghum Gulch dam and reservoir were located off-tract north of its planned location (Figure III-2), this would increase the storage capacity and possibly obviate the need for an additional dam. This possibility has not been examined in detail due to legal uncertainties related to use of off-tract lands. However, that option may be seriously considered if federal land policies change in the future. This particular plan would have the added benefit of allowing more room for processed-shale disposal on-tract, thus reducing pile height.

If a dam is required to supplement the Sorghum Gulch dam, a Scandard Gulch site would be preferred. The Scandard Gulch dam would be expected to have a maximum height of 180 feet and contain 10,000 acre-feet of water capacity. This reservoir would occupy approximately 150 acres of land.

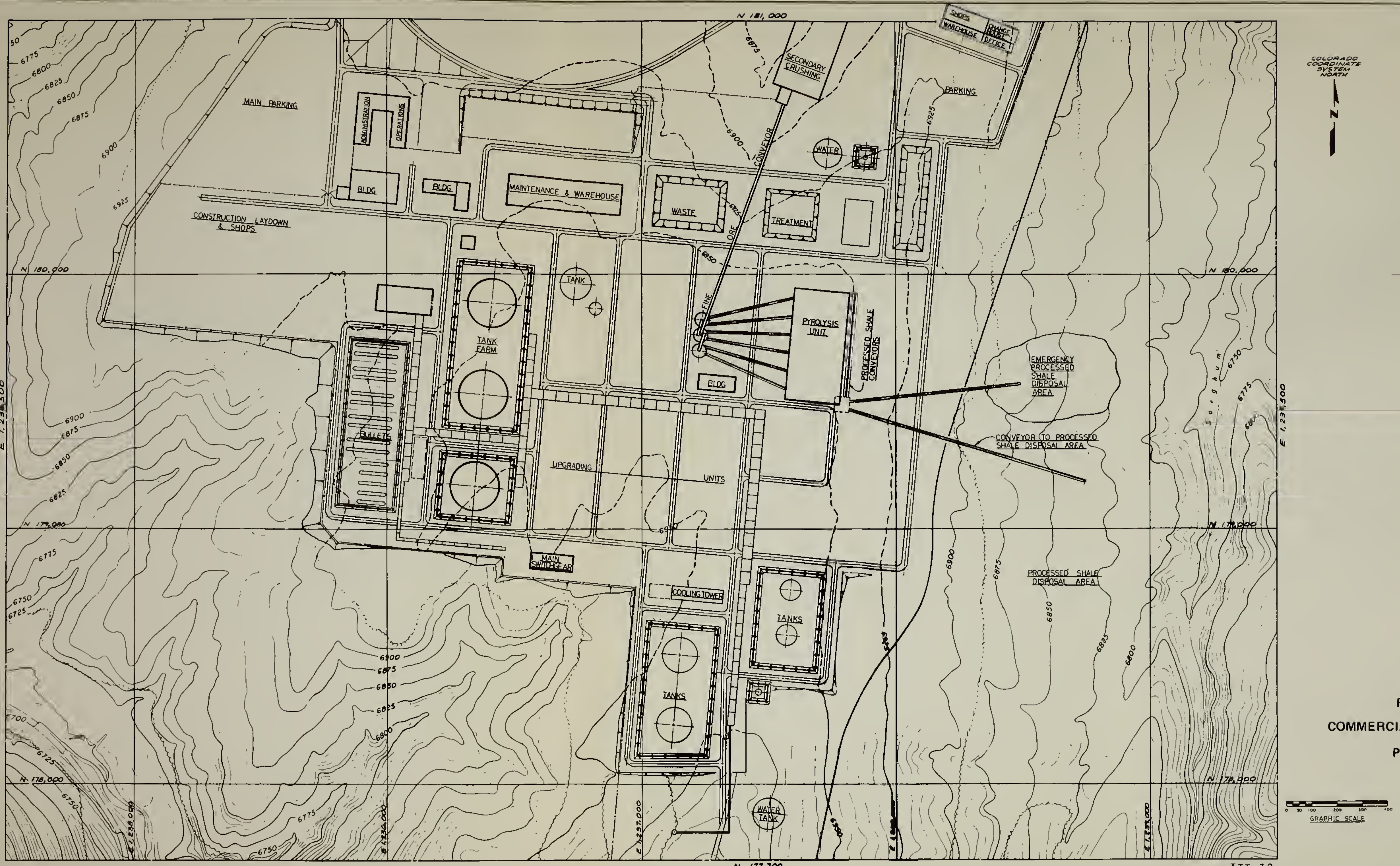


Figure III–4
COMMERCIAL PLANT FACILITIES
PLOT PLAN

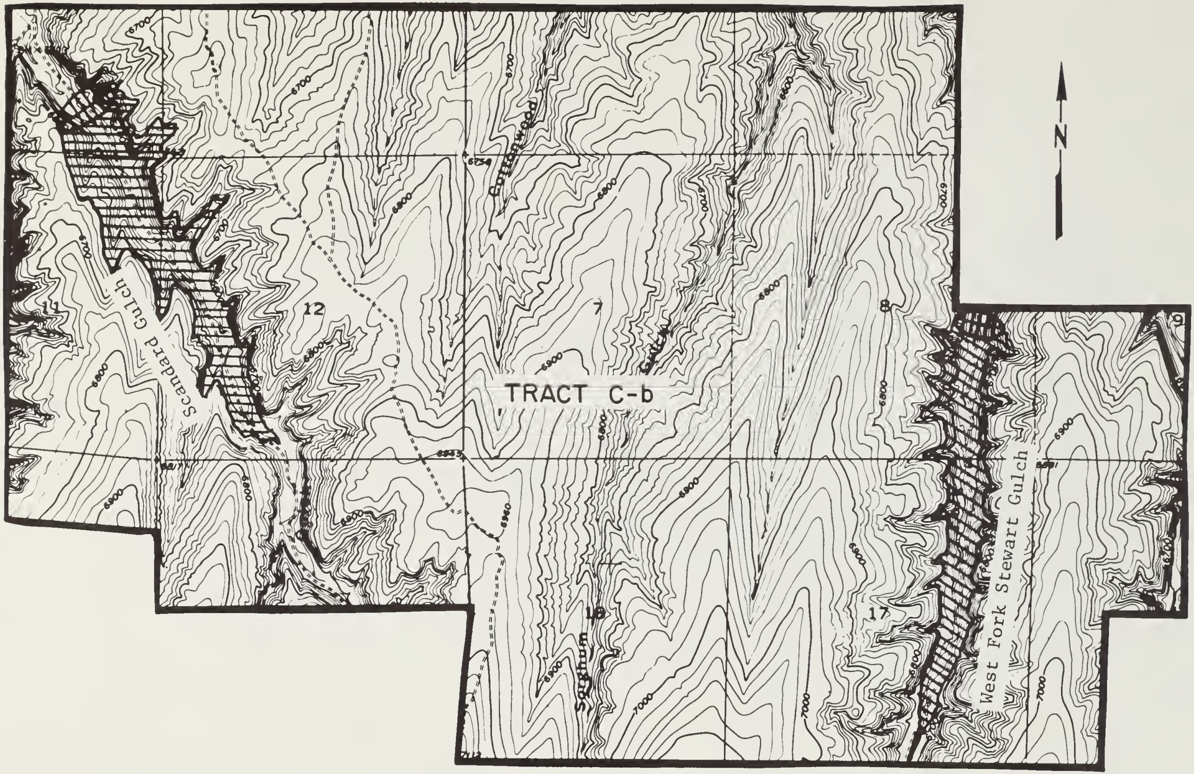


Figure III—5 ALTERNATE RESERVOIR SITES

An alternative to the Scandard Gulch site would be to locate a dam on-tract in West Fork Stewart Gulch. However, the West Fork Stewart Gulch site has several drawbacks compared to the Scandard Gulch site: 1) it has a larger drainage area which would increase the flood potential; 2) it is farther from the plant site; 3) it would require a larger dam; and 4) the surface area would be larger. The reservoir capacity curves for the two alternative dam sites are compared on Figure II-20 above. Table III-3 lists comparative data for the alternate storage reservoirs.

6. Support Facilities

Prior to commercial operation, permanent facilities including warehouse, storage yard, offices, vent shaft housings, guard houses, fencing, sanitary systems and other miscellaneous facilities will be constructed on-tract. These facilities will probably be constructed in the latter part of Phase II. The location and size of these facilities is shown in Figures III-2 and III-4.

D. Off-tract Facilities

The principal off-tract facilities which will be constructed in connection with the development of the Tract include:

- staging and terminal facilities
- water supply diversion facilities and water pipeline
- electrical transmission facilities
- communication system
- roads
- pipelines

Each of the off-site facilities is described in the following parts of this section. The corridor plan for the Tract, which describes the use and selection of corridors for off-tract facilities as well as Lessee's plans for corridor utilization, appears in Section V. M., Off-tract Corridors. Plans for off-tract facilities will require approval of one or more of the following: the Bureau of Land Management, U. S. Department of Interior, the State of Colorado; Rio Blanco and Garfield Counties; and private land owners.

1. Staging and Terminal Facilities

A staging facility is expected to be built near Rifle for use during construction and for eventual use during plant operation as a materials receiving and by-product shipping terminal. This area will occupy approximately 75 acres. A rail spur from the existing Denver and Rio Grande Western Railway main line will be laid to the staging facility. This spur will disturb approximately five to ten acres. During the construction phase, materials, vessels and equipment will be stored at the staging area and will be trucked to the Tract via State

Table III–3 POTENTIAL WATER STORAGE RESERVOIRS ON TRACT C-b

Dam Site	Maximum Dam Height (Feet)	Maximum Dam Elevation (Feet)	Maximum Reservoir Area (Acres)	Maximum Reservoir Volume (Acre-Feet)	Drainage Area (Square Miles)
West Fork Stewart Gulch	200	6720	160	12,000	14
Scandard Gulch	180	6640	150	10,000	8

Highway 13/789 and the Piceance Creek road. Later, the staging area will function as a terminal for shipment of sulfur, ammonia and possibly coke by rail, and to receive operating supplies shipped by rail.

By-product storage will be provided at the product shipping terminal. High-pressure vessels (bullets) for ammonia will be located at the terminal facilities. All high-pressure storage vessels will contain a relief valve to a flare. Each of the vessels will be surrounded by a system of water sprays providing complete coverage. The water sprays will be automatically triggered in the event of a fire. Storage vessels will be equipped with multiple sensors to detect any vaporous LPG or ammonia leakage. The entire storage complex will be interlocked to a system of local shutdown stations which will, upon activation, cause all operation to cease in the event of a malfunction.

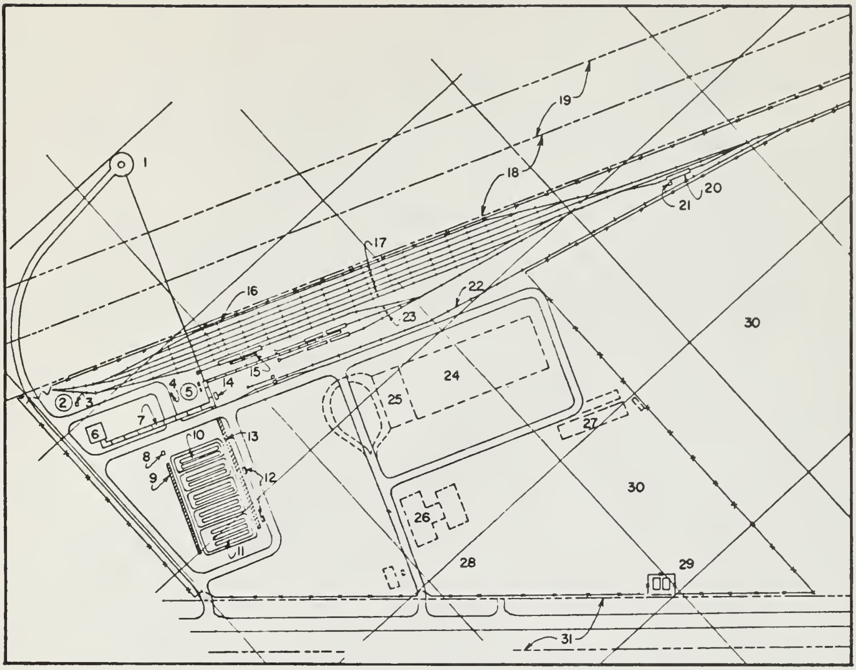
The railroad trackage leading to and within the terminal area will be of standard design conforming to American Railroad Engineering Association standards. Within the staging area a conventional track system will be constructed so the railroad will be able to make scheduled deliveries and pickups. It is anticipated that a loading dock and weigh stations will also be installed. Figure III-6 shows tentative plans for a typical terminal and staging area.

The two possible marketable solid by-products are sulfur and coke. Both of these materials will be transported by truck from the plant site to the terminal facilities. Transfer facilities will be constructed for loading into railroad cars for shipment.

The Rifle area is the presently preferred location for the staging area. An alternate staging area location near Grand Valley will also be considered. If the Rifle staging area is used for delivery and loading of construction equipment and materials, the Grand Valley facility may be used as a shipping point for liquid by-products received by pipeline.

2. Water Supply Facilities

As discussed in Section IV, the total consumptive water requirement for a 50,000 barrel per day complex is approximately 5500 gallons per minute (GPM) (12.3 CFS). The two basic sources for water supply are ground water and surface water. A certain amount of water will continuously enter the mine and must be pumped out. This water will be used in the plant complex to the extent possible. The best technology available has been used to define the Tract hydrology, but it is impossible to accurately predict, prior to actual development mining, the eventual magnitude of the mine inflow. Based on preliminary interpretations of the hydrology data, present best estimates indicate that some imported water will be required to supplement that produced from the commercial mine. Even if all plant consumption is met through ground water production, it may be necessary to develop a surface water



1 Flare 2 Fire water storage 3 Fire water pumphouse 4 Sulfur pit 5 Sulfur storage 6 Utility bldg 7 Pipeway 8 Control valves 9 Sleeperway 10 LPG storage 11 Ammonia 12 Pumps 13 Sleeperway 14 K.O. drum 15 Sulfur L.R. 16 Run around 17 Storage tanks 18 150' wide railroad R/W 19 Road R/W 20 Scale track 21 Scale house 22 Railroad spur 23 Loading tracks 24 Modular shop 25 Warehouse 26 Construction offices 27 Loading tracks 28 Parking 29 Waste treatment 30 Laydown area 31 Road R/W

NOTE: Facilities shown dashed are temporary only. They will be removed after construction is complete. Facilities shown solid are permanent.

Figure III–6 TYPICAL TERMINAL AND STAGING AREA

supply as a contingency system. See Section II for a general discussion of the expected ground water recovery.

Surface water for use in development of the Tract is potentially available from both the Colorado River and the White River. The Lessee holds water rights on the Colorado River and the White River. Additional private senior direct-flow rights or participation in one of the several private or public storage projects proposed on those rivers may be used.

The Final Environmental Statement for the Prototype Oil Shale Leasing Program notes that as much as 167,000 acre-feet of water per year may be available in Colorado for oil shale development from existing storage projects. According to the Department of the Interior, water is currently available for purchase from both the Ruedi and Green Mountain reservoirs.

A water service contract with the Bureau of Reclamation for water from the Reudi or Green Mountain reservoirs may be negotiated pursuant to Section 9(c)(2) of the Reclamation Project Act of 1939, as amended. Green Mountain Reservoir, a facility of the existing Colorado-Big Thompson Project, has a total storage capacity in excess of 152,000 acre-feet. Senate Document No. 80 (authorizing report for the Colorado-Big Thompson Project) states that 52,000 acre-feet of water will be committed to Western Colorado to replace water diverted to the Eastern Slope. Under a water service contract similar to that described above, water may be available to the Tract from the uncommitted portion of the remaining 100,000 acre-feet of Green Mountain Reservoir capacity, or from Reudi reservoir.

One direct-flow water right on the Colorado River that may be used is the Dow Pipeline Company conditional water right for 178 CFS from the Colorado River near Grand Valley. This right has a relatively recent priority date of November 10, 1966, with an appropriation date of January 24, 1955. The priority of this water right will not assure a constant supply of water during months of reduced river flow. Thus the C-b Shale Oil Project may need supplemental water, such as from Green Mountain or Reudi reservoirs to assure the successful operation of a shale oil plant.

It is anticipated that substantial amounts of ground water will be produced in conjunction with the mining operation. Ground water will be produced from mine-located dewatering wells and general runoff collection in the mine itself and from surface-located mine dewatering wells. The Lessee is in the process of making ground-water filings with the state of Colorado to obtain the legal right to use the ground water produced from these sources.

If the senior water supply of any party is reduced by mine dewatering operations, replacement water will be supplied to the injured party by either imported water from the Colorado or White rivers, or by temporarily yielding water from some of the participating companies' senior water rights on Piceance Creek. If significant volumes of tributary ground water are produced, the companies' senior water rights may be transferred to the mine-dewatering wells to make them senior water wells.

The Colorado River is the presently planned source of surface water. Although some ground water is expected to be produced from the mine, this amount is uncertain and the full water requirement of 12.3 CFS has been used as a design rate for a pipeline from the river to the Tract. Typical river intake and pump station facilities are illustrated on Figure III-7. The exact location of this facility cannot be fixed at this time.

The water pipeline will be a buried, electric-resistance-welded, high-strength steel line. It is anticipated that the line will be coated to reduce corrosion and improve hydraulic characteristics and will operate at peak pressure of around 1000 PSI. At least one booster pump station will be required to raise water from the Colorado River to the Tract.

Sediment in the river water will be removed by settling either at the river or at the plant site. If a single primary settling pond is used, the collected sediment will be removed with a dragline or by other equipment, depending on pond design. It is anticipated that this sediment will be used for revegetation work if ponds are located at the plant site. If more than one holding pond is used, the river water will be periodically diverted from one holding pond to another to allow collected sediment to be removed. Electrically driven pumps would transport the water through the pipeline to the booster stations, where additional pumps will move the water on to the plant site. The two pump stations will be designed for continuous operation and will be fully automatic. Periodic visits by operators and maintenance personnel will be required to insure a continuous supply of water.

An alternate water supply is presently being considered from the White River or its tributaries. If this source is used, the diversion facility and pipeline facilities will be essentially as described in Figure III-7. For a description of the alternate water pipeline corridor control plans and setting, see Section V. M., Off-tract Corridors environmental control plan and Section XIV, Off-tract Corridors environmental setting.

3. Electrical Transmission Facilities

The required electric load for the on-tract commercial operations, including the mining, crushing and processing units for commercial operations will be about 160,000 KVA connected load with an operating load of 120,000 KVA. For necessary reliability during Phase II, two

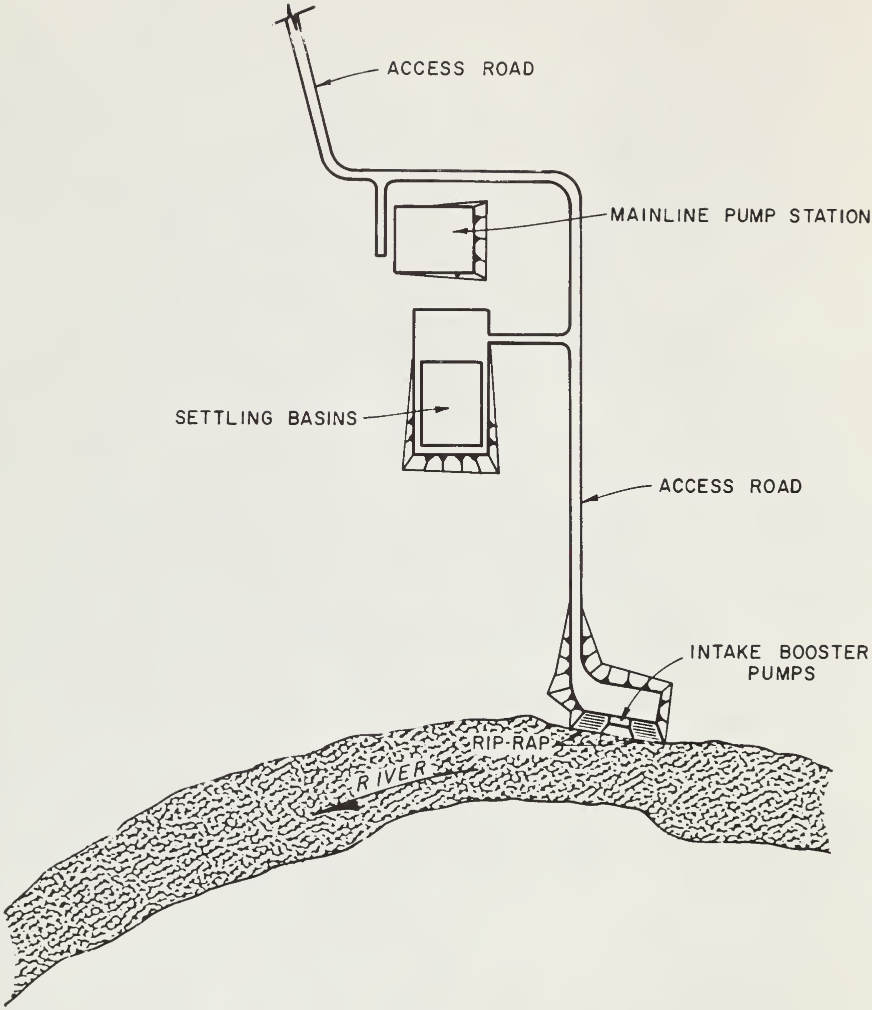


Figure III–7 TYPICAL RIVER INTAKE AND PUMP STATION FACILITIES

230 KV lines from alternate sources are contemplated. It is not yet certain which electric company will become the supplier. Discussions are being held with power companies to determine authority and ultimate sources of power. During Phase I, power will be imported to meet the development mining requirements described in Section II.

Although a determination of power line location will be determined by the power supplier, there are common actions related to any power line construction. Landforms in this area are such that many locations may not be accessible by surface transportation, and therefore helicopters may be required for moving men and equipment. The construction technique used will be adapted to the specific areas the power lines will traverse. Conventional equipment will include a variety of heavy-duty trucks and tracked equipment for construction and installation of transmission line towers, for stringing conductors, and for moving materials into difficult locations.

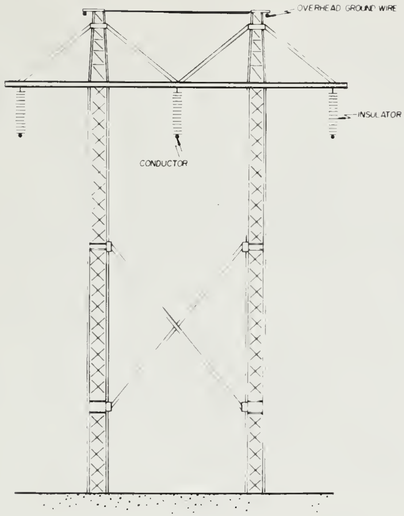
Standard wood pole K-frame structures with necessary guy wires will probably be used for the 230,000 volt facilities (Figure III-8). In those areas requiring helicopter construction, latticed self-supporting steel H-frame structures will be used if the wood pole K-frame weight exceeds the lifting capabilities of available helicopters (Figure III-8). The required conductor spacings and ground clearances for 230,000 volt lines, as shown in Table III-4, will be used.

4. Communication System

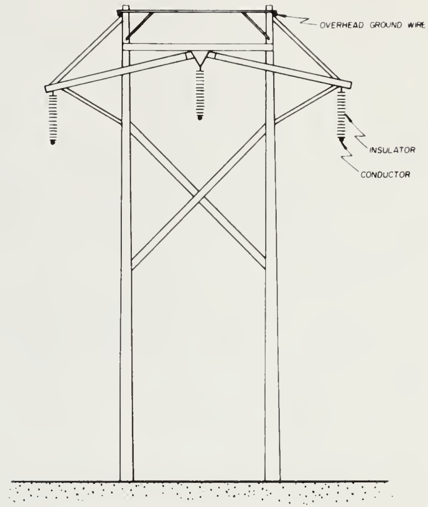
Although the final plant communication system has not been designed, it is anticipated that a buried telecommunication duct may be installed within the corridor from the Tract to Grand Valley. This duct would probably be on the order of a 6-by-6 inch or 9-by-9 inch concrete conduit. An alternate communication system such as microwave may be installed. This would require construction of a radio tower on the Tract.

5. Roads

A primary road corridor to the Tract will serve two purposes. One purpose is to provide a transportation corridor from a railroad to the Tract during the construction period, when frequent and sometimes heavy and oversized loads will be transported to the Tract. Another purpose is to provide a commuting route for workers to and from their place of residence, during both the construction and operating periods. Preliminary studies have shown that both these purposes could be served by either of two possible routes, both of which would be subject to obtaining appropriate approvals. The preferred route will extend from Rifle north to Rio Blanco on State Highway 13/789, northwest on Piceance Creek road (Rio Blanco County Highway 5), and south via the new access road to the Tract. An alternate route would extend northward from Grand Valley via Parachute Creek and cross the plateau to the Tract. Both routes are illustrated in Figure III-9.



SELF-SUPPORTING STEEL



WOOD K-FRAME

Figure III–8 TYPICAL STRUCTURES FOR 230,000 VOLT TRANSMISSION LINE

Table III–4 LINE CLEARANCES USED
FOR TRANSMISSION LINE CONSTRUCTION

Recommended Ground Clearances for 230,000 Volt Lines:

Railroads (Crossing)	44 feet
Roadways (Crossing)	37 feet
Trails (Crossing)	34 feet
Streams (Crossing) non-navigable	34 feet
Average Height of Structures	85 feet
Span Lengths	Vary in accordance with conductor terrain, and structure types used, i.e., flat to gently rolling terrain, span lengths average 700 feet.

Minimum Spacing Between Conductors:	20 feet

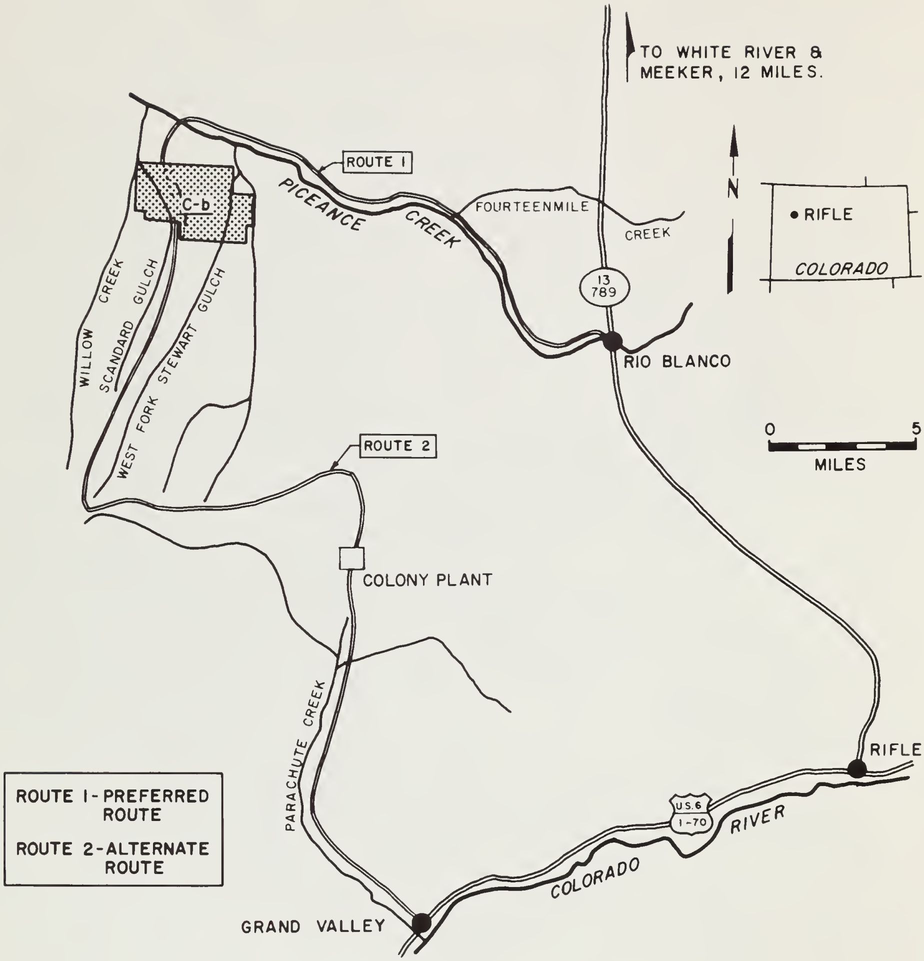


Figure III–9 ROAD ALTERNATIVES

The Rio Blanco route has the advantage of using existing roads and traveling with less incline. Substantial upgrading of the roads will be required. The Rio Blanco route is favored as the primary route for present planning. The Parachute Creek route would have the possible advantage of sharing an existing corridor, but would have the disadvantage of requiring that several miles of new road be constructed through difficult canyon terrain, over both private and public property.

Road construction design criteria are presented in Section II. I.

The use of unit trains as a means of transporting shale oil products has been considered, but does not appear to offer any economic or environmental advantages over conventional pipeline transportation.

6. Pipelines

a. Pipeline Corridors

Several pipelines will be constructed during Phase II. Pipeline corridors are described in Section V. M., Off-tract Corridors. Preliminary locations for pipelines are shown in Figure III-10 and are described below.

Preferred Multipurpose Corridor. This corridor would extend from the plant site on the Tract, along the ridge to the east of Scandard Gulch southerly to a point of connection with the proposed La Sal common carrier pipeline corridor running from the Colony plant to Lisbon Valley in southern Utah. This spur is the most probable path for product pipeline, by-product pipelines and water supply pipeline. The product pipeline from the Tract would connect with the La Sal pipeline at the southern end of the multipurpose spur. The by-product and water pipelines would continue easterly in the La Sal corridor from that point to the Colony property and then south down Parachute Creek valley to Grand Valley. A secondary service road would parallel the corridors.

Alternate Water Corridor. This corridor extends from the Tract to Piceance Creek and then easterly on the north side of the creek to Fourteenmile Creek. It would then proceed easterly along Fourteenmile Creek to Sheep Creek and then northerly to the White River. This corridor is the most likely corridor if White River water is used.

Preferred Road and Alternate By-Product Corridor. This corridor extends from the Tract to Piceance Creek valley, then easterly along the Piceance Creek road to a juncture with State Highway 13/789 at Rio Blanco, and then southerly on Highway 13/789 to Rifle. This corridor is the primary access and transportation corridor for construction equipment and employees and is an alternate corridor if by-products are transported by truck rather than by pipeline.

PROPOSED CORRIDORS:

—·— Preferred multi-purpose spur corridor (shale oil, by-products, water)

– – – Preferred water and by-products pipeline corridor

—··— Preferred road and alternate by-products corridor

········ Alternate water pipeline corridor

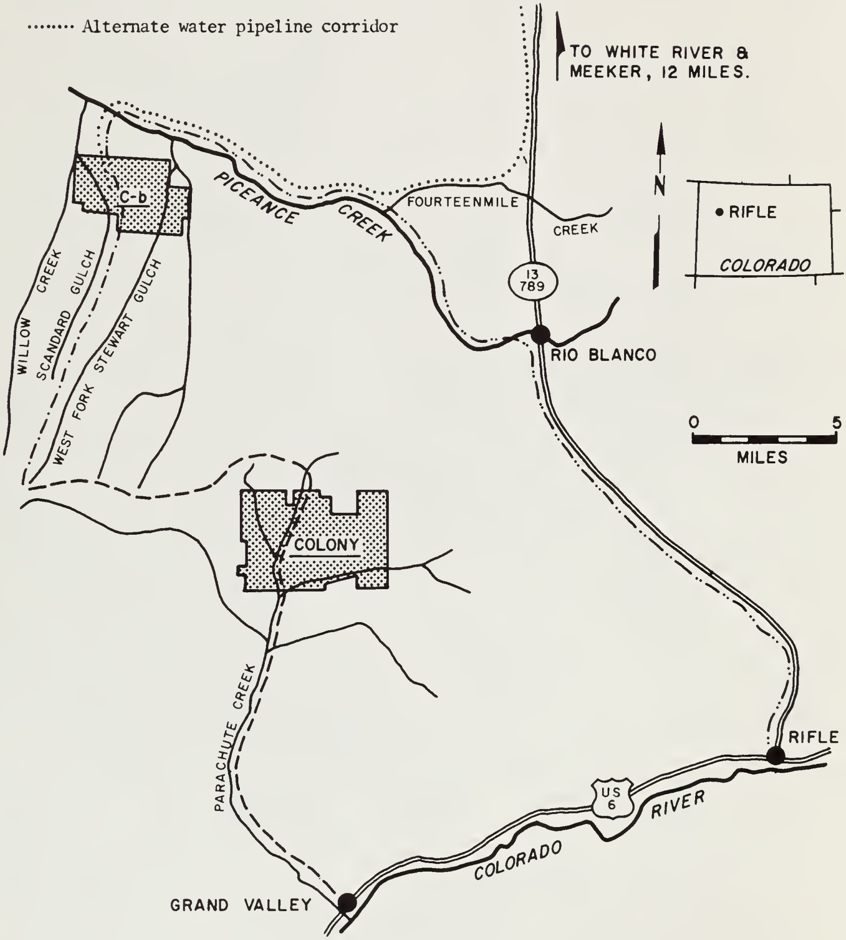


Figure III—10 PRELIMINARY PIPELINE LOCATIONS

b. Product Oil Pipeline

Construction and operation of the product oil pipeline from the junction of the Multipurpose Spur corridor to the Lisbon Valley, Utah will be the responsibility of a common carrier pipeline operator. Pipeline construction techniques and methodology are well-developed and proven. The specifications, characteristics, construction and operating procedures outlined below are typical pipeline construction techniques proposed for the La Sal pipeline.

Typical pipeline characteristics are given in Table III-5. They are based on an initial design throughput volume of 50,000 barrels per day, with the capability of expansion to 150,000 barrels per day. The pipeline will be designed in compliance with the Department of Transportation regulations Title 49 CFR, Part 195, "Transportation of Liquids by Pipeline." The pipe will be manufactured in accordance with the "American Petroleum Institute (API) Specifications for High-Test Line Pipe" - API Standard 5LX.

The hydraulics of the pipeline system, based on 50,000 barrels per day throughput, would require a pump station located at the origin on the Tract. A terminal located at Lisbon Valley, the terminus of the pipeline, will be utilized to receive oil from the pipeline, provide interim storage facilities and transfer oil to the existing Pure Transportation Company pipeline.

Provisions for an intermediate pump station in the event of a later increase in capacity will be included. The location of this pump station would be somewhere south of Moab, Utah. The exact location has not been determined at this time.

The Tract station, located inside the storage and loading facilities area of the shale oil processing complex, would boost the pressure sufficiently to deliver the product to the Lisbon terminal. The pressure at the terminal will be controlled through pressure reducing valves.

The Tract pump station would be equipped initially with two 900 horsepower (HP) electric motor driven pumps, each having a capacity of 50,000 barrels per day. Only one pump would be on-line at any one time, the second pump being on standby. Provisions would be made within the pump stations for a third 900 hp pump to accommodate a higher throughput rate if desired at some later date, at which time two pumps would be on-line at any one time, the third pump being on standby.

The Lisbon Terminal will be equipped with two 80 HP electric motor-driven transfer pumps, each having a capacity of 2500 barrels per hour. Only one pump would be on line at any one time, the second pump being on standby. Provisions would probably be made within the terminal for a third 80 HP pump to accommodate a throughput rate of 100,000 barrels per day at a later date.

Table III–5 PIPELINE CHARACTERISTICS [a]

Section Location From	Section Location To	Section Length (miles)	Outside Diameter (in.)	Wall Thickness (in.)	Working [b] Pressure (psi)	Cumulative Length (miles)
Lisbon Terminal	Moab	32.8	16.000	0.375	1755	32.8
Moab	Colorado River	2.2	16.000	0.406	1900	35.0
Colorado River Crossing		3.8	16.000	0.500	2340	38.8
Colorado River	N. end Moab Canyon	4.7	16.000	0.406	1900	43.5
N. end Moab Canyon	N. end Arches Nat. Park	30.5	16.000	0.375	1755	74.0
N. end Arches Nat. Park	East Salt Creek Canyon	71.0	16.000	0.406	1900	145.0
East Salt Creek Canyon	Tract C–b Shale Oil Plant	49.0 [c]	16.000	0.250	1170 [d]	194.0

NOTE: This table is subject to change depending upon final route profile and length.

(a) Pipe specifications - Grade X-52 (API Standard 5LX).

(b) Maximum allowable working pressure for oil based on 72% of yield strength.

(c) Alternate route up the Middle Fork Stewart Creek would increase the length of the East Salt Creek Canyon Section to approximately 54 miles.

(d) Subject to change pending final profile.

The product line at the Tract pump station and at the Lisbon terminal would be monitored for temperature, flow rate and pressure. Pressure alarms will be installed to immediately notify operating personnel of upset conditions. Sump tanks to accommodate flow from relief valves and oil strainers placed in the incoming product line will be located at each facility. The sump tanks will be equipped with level-control systems to prevent overflow. All critical valves in the system will be motor operated.

Provision for inserting a scraper (scraper traps) to periodically clean the inside of the pipeline will be made at the Tract pump station. Removal of the scraper will occur at the Lisbon terminal. The scraper traps will also be utilized for initial cleaning, testing and purging operations prior to placing the pipeline in service.

Mainline valves will be placed on the pipeline system in accordance with Department of Transportation regulations Title 49 CFR, Chapter 1. In particular, the following types would be located as indicated below:

Outgoing pipeline from the Tract pump station:

16 in. - 600 series motor-operated gate valve
16 in. - 600 series manually operated gate valve

Incoming pipeline to Lisbon terminal:

16 in. - 900 series manually operated gate valve
16 in. - 900 series motor-operated gate valve

Scraper trap valves:

16 in. - 600 series motor-operated gate valves at the Tract station
16 in. - 900 series motor-operated gate valves at Lisbon terminal pump station

Colorado River crossing (each side):

16 in. - 900 series motor-operated gate valves

Various mainline locations, depending upon topography:

16 in. - 600 and 900 series motor-operated gate valves
16 in. - 600 and 900 series manually operated gate valves

The motor-operated valves at the Colorado River crossing will be operated remotely. Manually operated valves on the mainline will be utilized to isolate sections for maintenance purposes or in the event of pipeline failure.

Pressure ratings of the various series are:

600 series - 1440 psig working pressure
900 series - 2160 psig working pressure

The activities associated with pipeline construction include: clearance of right of way; stringing of pipe (delivering cleaned and coated pipe to the right of way); ditching; bending and laying; welding; insulation and corrosion protection; lowering and backfilling; waste disposal and cleanup; hydrostatic testing; and restoration including revegetation. A discussion of each of these activities is given in the following paragraphs.

Clearance and Restoration of the Right of Way. The right of way for pipeline construction will generally be 50 feet wide except in any areas specifically designated as environmentally sensitive, at which locations special construction techniques would be employed. The centerline of the pipeline will be staked prior to clearing and grading with right-of-way boundaries delineated.

The right of way width is cleared of only those above ground obstacles which will interfere with the work. After clearing, the right of way is graded to permit transit and operation of construction vehicles and equipment and to permit placement of the pipeline at the desired elevation. However, the contractor will be instructed to do as little grading of the right of way as possible to minimize disruption of existing vegetation. Where possible, trees will be left standing in the right of way. Right-of-way restoration will be accomplished in accordance with the appropriate procedures described in Section V. K., Erosion Control and Surface Rehabilitation plan, and V. M., Off-tract Corridors.

All filled areas will be thoroughly compacted and stabilized to minimize erosion and will be contoured so as not to adversely affect the use or appearance of the filled and surrounding area upon completion of the pipeline project.

Grading of the right of way will be performed in a manner which will minimize interference with existing drainage patterns. All grading will be finished to maintain the original drainage or water flow conditions as nearly as practicable.

Stringing the Pipe. Upon completion of clearance and grading, pipe will be delivered to the right of way and strung to the length required, minimizing the accumulation of short lengths. Trucks will be utilized for hauling the pipe and in most cases would proceed along the cleared right of way. If the use of private roads and bridges is necessary, the permission of owners, tenants or lessees will be obtained and the roads and bridges will be maintained in a safe and usable condition. Any damage caused by such use will be promptly repaired.

Pipe strung on the right of way will be placed to permit the normal passage of livestock and equipment across the right of way.

Ditching. Ditching includes all excavation work required to provide a ditch of the specified dimensions and depth of pipe cover. Typical ditch requirements are shown in Figure III-11. Ditching will be accomplished with a ditching machine or backhoe where soil conditions dictate.

In carrying the pipeline beneath intersected pipelines, ditching depth will provide a minimum of 12-inch clearance between the two pipelines. For ditching across or adjacent to roads, highways, railways, drainage ditches, irrigated land, and areas requiring river crossings, the excavation will be carried to such additional depth as may be necessary to meet the requirements of landowners and any public or private authority having jurisdiction. At all uncased road crossings, the pipeline will have a minimum cover of four feet.

The blocking of normal drainage by the ditching operation will be prevented. Temporary culverts across the ditch and openings in the spoil bank will be provided wherever necessary to keep the normal drainage routes open.

Special precautions will be observed to prevent damage to underground structures (i.e., other pipelines, cables or conduits) that may be encountered along the pipeline route.

The pipeline route will be selected to minimize the necessity for explosive blasting. If blasting is required, all applicable laws and regulations governing the storage, handling and use of explosives will be followed. All blasts will be blanketed sufficiently to minimize hazard and damage from flying debris and to limit the dispersal of debris.

Bending and Laying. The pipeline will conform to the terrain and fit the contour of the ditch both vertically and horizontally. All pipe bends will be made in the field except special bends pre-designed for use in specific areas. Expanding mandrel-type bending machines will be utilized in a manner which will not cause an increase in pipe diameter. Any pipe with a bend that is buckled or that is flattened beyond tolerance, or that causes the pipe to lay improperly in the ditch, will be cut out and replaced.

Welding. All welding will conform with the requirements set forth in the American Petroleum Institute API STD 1104, "Standard for Welding Pipe Lines and Related Facilities." Tests welds will be cut from the line for testing. Only qualified welders will be used. Project personnel will supervise and witness qualification tests for welders.

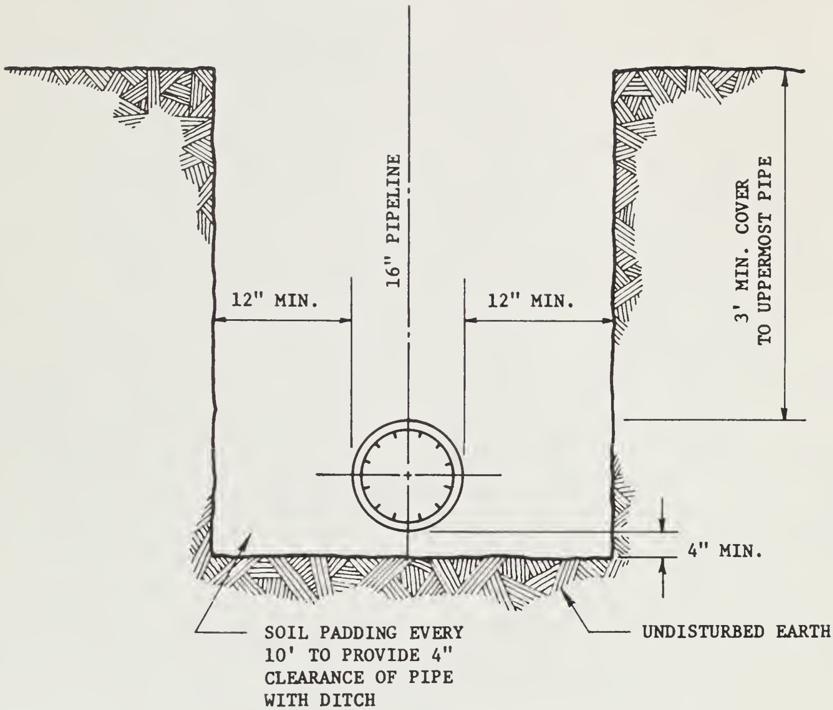


Figure III–11 TYPICAL PIPELINE DITCH DESIGN

Line-up and welding consist of several operations which may extend for 1000 to 2000 feet in open country. Prior to welding, pipe joints will be swabbed clean of all internal contamination such as earth, sand, loose mill scale and other extraneous material. The stringer bead weld is followed by a hot pass, filler passes and cap pass. After welding, the line remains on skids for final field wrapping at joints.

In accordance with applicable Department of Transportation regulations, radiographic inspection of no less than 10% of the girth welds will be made. In addition, any section of pipe where a failure in girth weld would be difficult to repair, such as beneath a river, will be 100% inspected. Sections of pipe to be encased, pipeline within the limits of any incorporated subdivision of a state government, and pipeline within populated areas will have all girth welds radiographically inspected for 100% of their circumference.

Insulation and Corrosion Protection. After welding procedures have been completed and prior to lowering the pipeline into the excavation, the entire pipeline will be coated and wrapped to protect against corrosion. The pipe will be coated with a 3/32-inch minimum thickness of coal-tar-base enamel preceded by a compatible primer. A single wrap of fiberglass and a single wrap of asbestos felt will be placed over the coal-tar enamel. This procedure will be followed for all pipe sizes except the 1/2-inch-wall-thickness pipe where a 3/16-inch minimum thickness coating will be applied with a double wrap of fiberglass and a single wrap of asbestos felt. Where pipe casings are used, the outside walls of the casings will be cleaned and brush-coated with coal-tar enamel prior to installation.

Integrity of the finished coated system prior to backfilling will be tested with a "holiday" detector (a device to detect invisible flaws in the coating).

Electrolysis test stations will be installed at all crossings with other pipelines, where casing is used under road or railway crossings, at all buried insulated flanges or special insulated fittings, and elsewhere at no more than one mile distance between test points. Insulating flanges would be installed at a C-b pump station and at the Libson Valley terminal to electrically isolate these facilities from the pipeline.

Lowering and Backfilling. Prior to the lowering of the pipeline into the ditch, the ditch will be cleaned free of rocks, hard clods and any roots or extraneous material or objects. An earth pad will be placed in the ditch to support the weight of the pipe and provide a minimum of four inches of clearance between the pipe and the bottom of the ditch on straight runs and 12 inches of clearance along overbends, and to allow snug fit of pipe at sags. Any rock-bottom ditch which is ragged will require continuous earth padding between the pipe and the ditch bottom.

The pipe will be lowered into the prepared ditch with the use of side boom tractors utilizing slings of sufficient width to avoid pressure damage to pipe coatings. Cathodic protection installations will be installed as the final operation of lowering. The installation will be inspected before backfill is placed.

The backfilling operation will follow the lowering-in of pipe as closely as possible. Backfilling will be scheduled so that no more than one mile of lowered-in line will be exposed, at any given time. When backfilling, no rocks, clods or other hard objects will be permitted to fall on the coated pipe. The pipe will be covered with soft earth to a depth of six inches before any rocky material will be placed in the ditch. Backfill material will contain an excess of soil in the mixture of soil and small rocks. After the ditch has been filled to the level of the surrounding ground, the fill will be compacted. Excess surface soil will be spread evenly over the disturbed area, leaving a crown to allow for settling.

When backfilling on hillsides or sloping ground, furrows or terraces across the pipeline right of way will be provided to direct the flow of water into natural drainage courses and away from the pipeline ditch.

Waste Disposal and Cleanup. All waste material will be continuously accumulated and disposed of in authorized disposal sites (sites to be designated in cooperation with local and state regulatory agencies). Woody plant materials, i.e., branches, shrubs and tree trunks, could be run through a chopper, reduced to a small size, and distributed over the right of way to produce mulch material. Portable sanitary facilities will be provided for construction crews as work proceeds along the right of way.

Immediately following the completion of the backfilling operation, the right of way will be cleaned up. All surplus and defective materials will be picked up and removed to a pre-selected disposal area. The earth on both sides of the pipeline ditch which will have been disturbed during the construction of the pipeline will be graded and returned as closely as possible to its original contour. All temporary fills, culverts, and bridges will be removed and the area returned to a pre-construction state, as nearly as possible. Farm land will be restored so that normal cultivation can be resumed.

Hydrostatic Testing. The pipeline system will be hydrostatically tested to ensure that all parts of the pipeline system meet design specifications. The pipeline contractor will employ a specialized crew equipped to perform the hydrostatic testing as soon as practicable after each segment of the line is completed.

Upon satisfactory completion of the hydrostatic testing of a given section, a Hydrostatic Test Certification will be prepared giving all pertinent information, such as identification of the segment tested, location of the pressurizing pump and instrumentation, pressure-volume graphs, charts of pressures recorded, and records of leaks, breaks and repairs.

Following completion of hydrostatic testing of the entire pipeline, the test water will be displaced with oil. Batching scrapes will be placed in the interface to prevent oil contamination of the test water.

The test water will be discharged into natural drainage courses at manageable flow rates. During discharge of the water, samples will be analyzed and appropriate steps will be taken to ensure that test water meets existing water quality standards before discharge.

c. By-products Pipelines

The most economical method of transporting ammonia and liquified petroleum gas (LPG) is by pipeline. The quantity produced will vary, depending upon the amount of product upgrading undertaken in the plant. Ammonia and LPG production rates are about 140 short tons and 4200 barrels per day, respectively.

As discussed in Section III. D. 6., by-product pipelines are planned to parallel the oil pipeline to its connection with the La Sal pipeline, and then run through the Parachute Creek corridor to Grand Valley.

The liquid ammonia and LPG lines will be sized to accomodate the proposed amount of product. Since both products are gases at ambient temperatures, the lines must operate under sufficient pressure to maintain the liquid state. Pipe wall strength will be selected to withstand the full hydrostatic pressure plus vapor pressure when the line is shut in at the Grand Valley terminal. A pressure let-down station will be provided at the Grand Valley terminal to ensure that the product pressure delivered to the vessels does not exceed normal operating pressure and inadvertently lift the relief valves. An excess flow valve sensor at the plant site will automatically shut off feed to the line in the event of a pipeline rupture. A hydropneumatic accumulator will be installed at the Grand Valley terminal to dampen any temporary pulses in pressure resulting from the rapid closing of valves.

Both lines will be wrapped and coated for corrosion protection. Pipeline construction techniques will be similar to those outlined for the oil pipeline (Section III. D. 6.). The much smaller size of the by-product lines will allow more rapid construction and less overall impact. All construction and operating procedures will comply with government regulations 49 CFR Part 1975, "Transportation of Liquids by Pipeline," and 49 CFR Part 110, "Carrier by Pipeline Other Than Gas and Water." A discussion of spill contingency planning for these lines is located in Section V. L., Oil and Hazardous Materials Spill Contingency Plan.

Since the by-product pipelines will parallel the oil line and/or the water line for much of their length, overall impacts and construction costs will be minimized by utilizing a common right of way and construction corridor. Typical ditch dimensions for a four-pipeline corridor are shown in Figure III-12. The right-of-way width required for such a system will be greater than for a single pipeline, but less than required for entirely separate lines. The width of the working areas required for construction of a typical multipurpose pipeline is shown in Figure III-13.

d. Water Pipeline

A discussion of the water pipeline appears in Section III. D. 2.

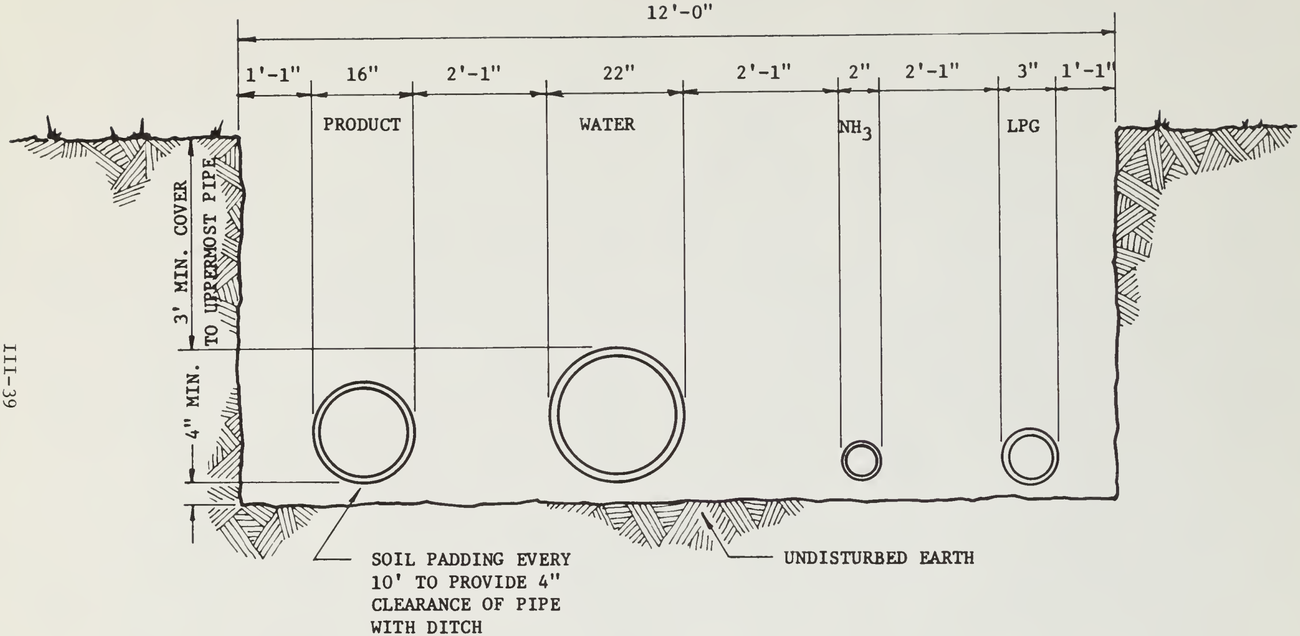


Figure III–12 TYPICAL MULTI-PIPELINE DITCH DIMENSION

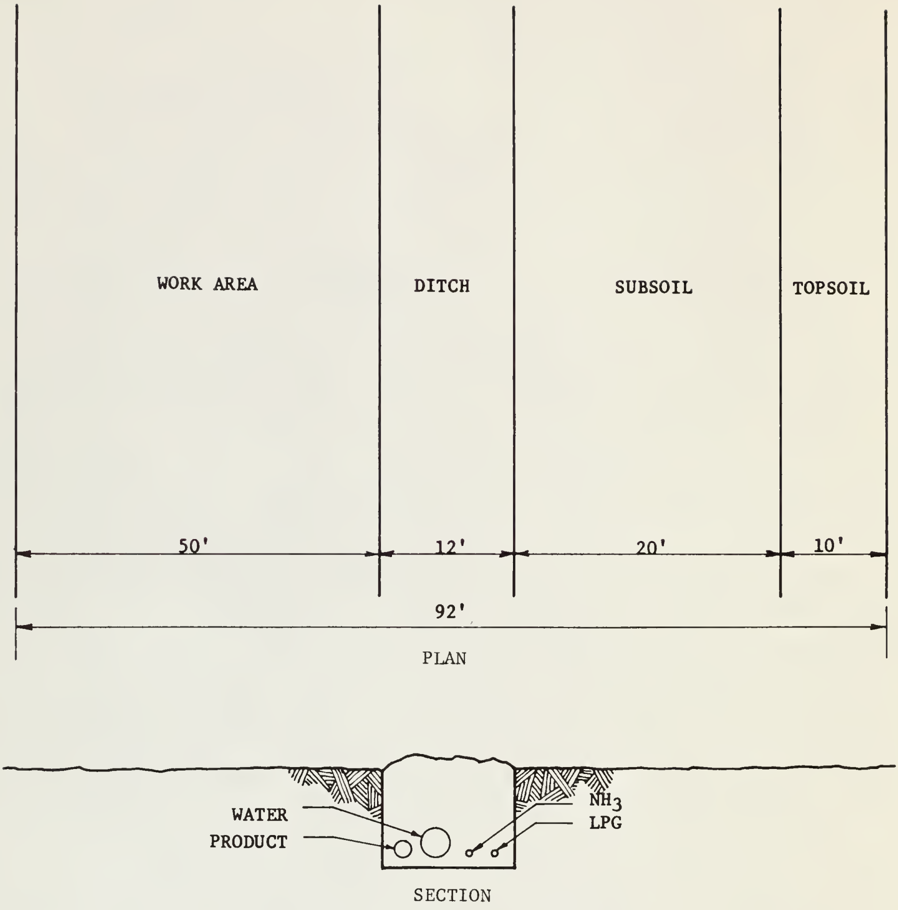


Figure III—13 SURFACE USE – TYPICAL MULTIPURPOSE CORRIDOR

IV

Phase III - Plant Operation
Phase IV - Post Operation

IV. Phase III - Plant Operation
Phase IV - Post Operation

IV. PHASE III - PLANT OPERATIONS AND PHASE IV - POST-OPERATIONS

This section contains a description of activities which will occur during Phase III and Phase IV. Phase III begins with plant start-up, which is projected to commence approximately 9 years after DDP approval, and continues thereafter for a period of 20 years or until plant shutdown after reserves are exhausted. Phase IV is the period following the conclusion of plant operations during which the plant facilities will be decommissioned and the land restored.

A. Introduction and Summary - Phase III

Plant operations are expected to commence approximately 9 years after DDP approval. After start-up, plant operations should stabilize and continue for approximately 20 years or until reserves are exhausted. The following materials summarize Phase III activity.

Phase III Development Schedule. Figure IV-1 shows the activity schedule for all activity prior to and during Phase III.

Phase III Plot Plan. Figure IV-2 presents the preliminary plot plan showing all major facilities which will be constructed prior to and during Phase III.

Phase III Manpower Requirements. Figure IV-3 shows the estimated manpower requirements for Phase III.

Phase III Surface Disturbance. Table IV-1 lists by year the surface acreage which will be disturbed prior to and during Phase III.

B. Schedules and Manpower

As soon as the Phase II construction has been completed, all systems will be debugged as the facilities are subsequently started up. It is anticipated that this plant start-up activity will continue for approximately six months before actual commercial operation is undertaken. In accordance with current schedules, as shown in Figure IV-1, plant start-up will commence in the 9th year after DDP approval, with commercial production six months later.

Since a prototype oil shale development provides the basis for estimating manpower requirements, all staff projections must of necessity be tentative. The range of current estimates of the necessary staffing for operation of a commercial oil shale complex is shown in Figure IV-3.

Regardless of the final maximum employment total, all projections indicate that the peak will be achieved as a result of a somewhat gradual buildup. Figure IV-3 above indicates that this buildup will commence in the 5th year after DDP approval, or approximately four years before plant start-up is scheduled. This early staffing is required both to develop the commercial mine prior to plant operations and to permit smooth transition from construction into operation. In Figure IV-3, a projected range has been shown for the nominal plant operation staff. Because of the range of manpower estimates, it is difficult to project a skills breakdown for this phase of development. However, using the upper range of operating manpower projections with a total of approximately 1200 personnel as representative, the overall skills breakdown is expected to be similar to that shown in Table IV-2.

C. Mine Operations

1. Mining Zones

The mine interval of primary interest at the present time is a section within the Mahogany zone ranging from 74 to 83 feet in thickness. This interval has an average richness of about 36 gallons per ton (GPT). The main mine interval has been divided into two subdivisions: 1) a 45 ± foot upper bench averaging 38.7 GPT; and 2) a 31 ± foot lower bench averaging 32.3 GPT. An alternative mining interval presently under consideration encompasses the lower 68 ± feet of the main mine interval. This restricted mine unit averages 36.6 GPT. A detailed description of these units is presented in Section VIII.

The optimum mining zone thickness will depend upon the geotechnical properties of the rock mass and upon mining and retorting costs. For example, the maximum extraction ratio for a 75-foot mining zone using room-and-pillar mining techniques has been estimated to be from 30% to 50%. For a 35-foot mining zone, this ratio may be 40% to 60% or possibly somewhat higher. This difference in extraction efficiency is attributable to the difference in rock properties of each interval and other factors. In going from a thinner to a thicker mining zone, some zones of weaker rock must be included and pillars must be larger. Thus, it is possible that more total oil could be recovered from the Tract by mining a thinner and richer zone than could be obtained by mining a thicker and leaner zone. In addition, use of modifications of conventional room-and-pillar mining techniques, including planned caving, would result in larger recovery ratios.

The final choice of the mining zone will be made after a detailed structural and economic analysis is available. This analysis requires rock mechanics data which will not be available until after some actual development mining has been conducted. Within the selected mining zone, the mine will ultimately traverse essentially all of the leased property, except those areas lying directly under the surface facilities, as illustrated in Figure IV-4. Feasibility of recovering the plant

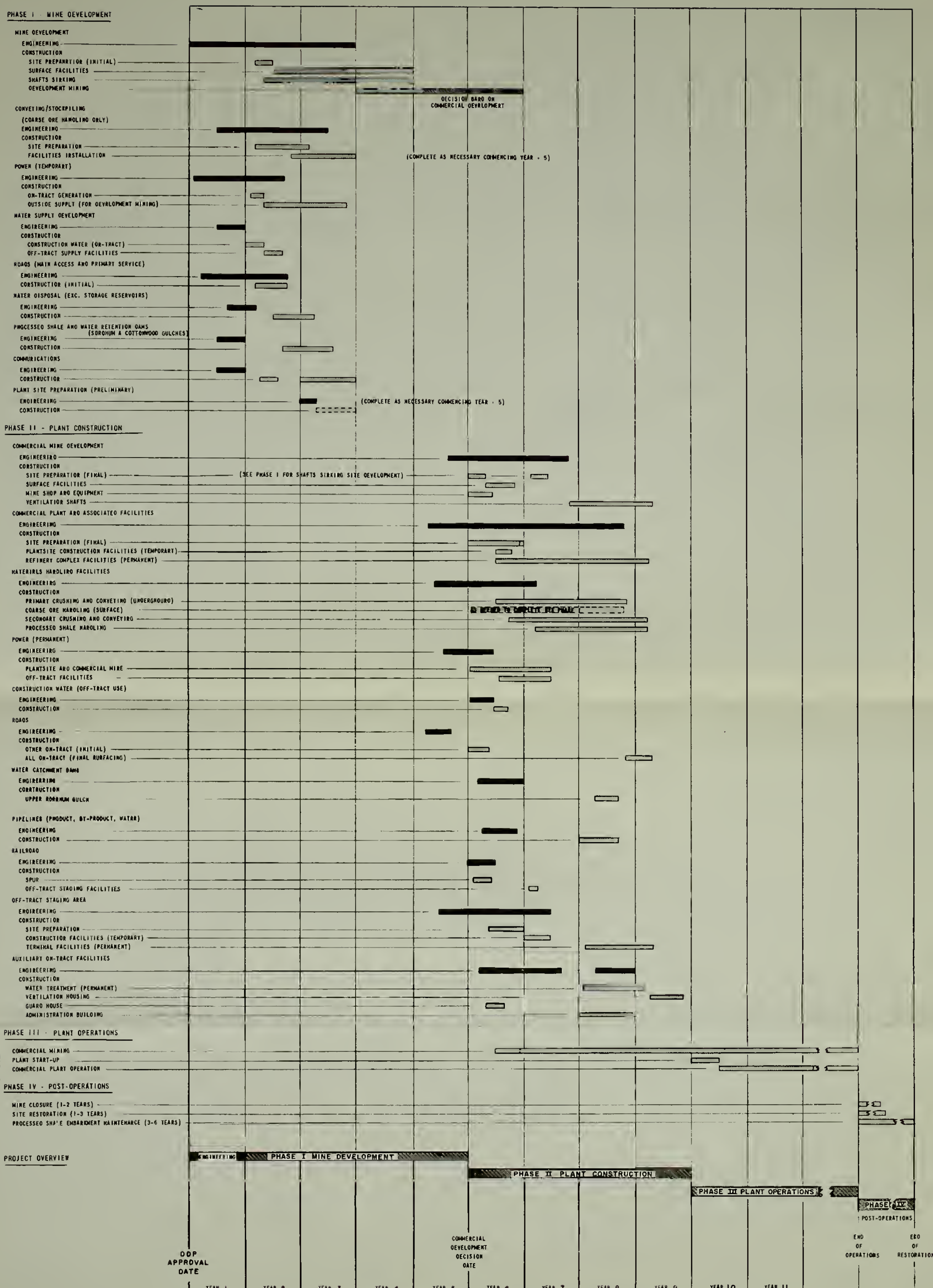


Figure IV—1 PROPOSED DEVELOPMENT SCHEDULES
C-b SHALE OIL PROJECT

Figure IV–2 PROJECT PLOT PLAN
PHASES I, II, AND III

Figure IV–3 PROJECT MANPOWER ESTIMATE

Table IV–1 PHASE I, II AND III PROPOSED SURFACE DISTURBANCE BY YEAR

AREA DISTURBED (ACRES)

DDP APPROVAL

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to end of operation	Total by Activity
PHASE I												
Mine Surface Facilities		25-35										25-35
Coarse Ore Conveyor		5-10										5-10
Coarse Ore Stockpile (Initial)		35-40										35-40
Road Construction (New)												
-Primary Tract Access		40-50										40-50
-Dam Access		10-15										10-15
-Primary Coarse Ore Conveying/ Stockpiling		5-10										5-10
Dam Sites (Sorghum & Cottonwood Gulches)		15-25										15-25
Construction Water		5-10										5-10
Reservoir (Sorghum Gulch)		5-10	10-15									15-25
PHASE II												
Truck Maintenance Facility						10-15						10-15
Plant Site						150-200						150-200
Processed Shale Handling System							15-20					15-20
Power R-O-W						5-15						5-15
Pipeline Corridor R-O-W								10-20				10-20
Road Construction (New)												
-Ventilation Housing Access						15-20						15-20
-Secondary Coarse Ore Stockpile						2-5						2-5
-Water Catchment Dam							10-15					10-15
Auxiliary Bldgs.								25-30		3-5		28-35
Coarse Ore Stockpile (Temporary)								25 35	15-20			40-55
Dam Site (Scandard Gulch)**							25-40					25-40
Reservoir (Scandard Gulch)**								40-70	50-100			90-170
PHASE III												
Processed Shale Pile										*	1000-1200	1000-1200
TOTAL BY YEAR		145-205	10-15			182-255	50-75	100-155	65-120	3-5	1000-1200	1555-2030-

*Acreage disturbance by processed shale pile will commence in Year 10 and continue to end of operations resulting in 1000-1200 total acres.

**Dam and reservoir constructed only if additional mine dewatering storage is needed.

Table IV–2 BUILDUP OF COMMERCIAL PLANT OPERATIONS AND MINE DEVELOPMENT PERSONNEL

Year After DDP Approval	Personnel Description	Number of Employees by Year	Cumulative Number of Employees
4	(S) Mine Supervisors and Clerical	22	
	(H) Mine Operators	26	
	(H) Mine Maintenance	11	
		59	59
6	(S) Management and Secretarial	26	
	(S) Technical Services	18	
		44	103
7	(S) Technical Services	22	
	(S) Miners Salary Management	53	
	(S) Administrative Support	25	
	(H) Mine Operators	15	
	(H) Mine Maintenance	15	
		130	233
8	(S) Refinery Supervisor	16	
	(S) Maintenance Management	31	
	(H) Mine Operators	15	
	(H) Mine Maintenance	15	
		77	310
9	(H) Plant Operators	108	
	(H) Plant Maintenance Workers	183	
	(H) Crushing/Disposal Support	86	
	(H) Mine Operators	22	
	(H) Mine Maintenance	20	
		419	729
10	(H) Crushing/Disposal Support	57	
	(H) Mine Operators	192	
	(H) Mine Maintenance	115	
		364	1,093
	ALL ADDITIONAL PERSONNEL ARE HOURLY MINERS		
15	(H) Mine Operators	30	1,123
16	(H) Mine Operators	22	1,145
17	(H) Mine Operators	8	
	(H) Mine Maintenance	1	
		9	1,154
20	(H) Mine Operators	16	
	(H) Mine Maintenance	2	
		18	1,172
	TOTALS	1,172	1,172

(H) - Hourly
(S) - Salaried

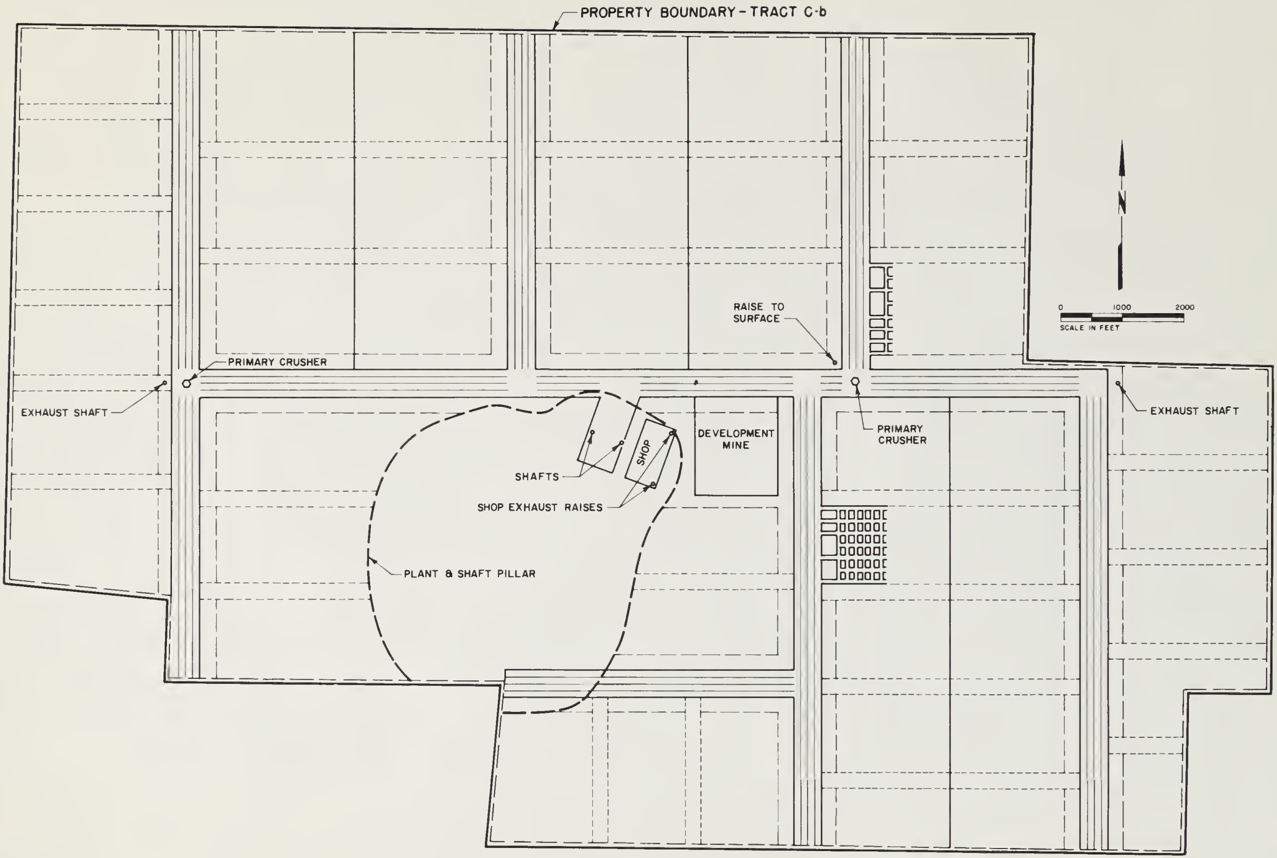


Figure IV—4 COMMERCIAL MINE LAYOUT

pillar will be evaluated in the latter stages of the operation when sufficient information has been obtained.

Assay information from the core holes drilled on-tract has been evaluated to determine whether any commercially mineable intervals are present in addition to the Mahogany zone. No other zones are believed to be mineable at the present time. There is a nominal 55-foot section of oil shale with a lower oil content than the Mahogany zone several hundred feet below the Mahogany zone. This lower zone is known as the R-4 zone. There are no present plans to mine this zone. If this shale is mineable, it is anticipated that room-and-pillar extraction ratios would be on the order of 25% to 50%. Changing technologic and economic factors could alter the situation in the future, and an on-going evaluation of the R-4 zone will be carried out. In any event, the mining of the Mahogany zone oil shale should not interfere with development of deeper zones at a later date.

Nahcolite and dawsonite which occur in abundance in the north-central part of the Piceance Creek basin are present in relatively small amounts on the Tract. Core analyses of the Mahogany zone beneath the Tract indicate that the dawsonite content is significantly less than 2% by weight. Nahcolite content over the interval was too small on visual inspection to warrant detailed analysis. Since the Tract is peripheral to the main area of nahcolite and dawsonite deposition in the "lower oil shale zone," considerably smaller amounts of these minerals are present beneath the Tract than in the basin depocenter. Any further plans for developing the R-4 zone would, however, include a detailed evaluation of the nahcolite and dawsonite potential.

2. Mine Design

The method of extraction selected for initial recovery of the oil shale resources under the Tract is conventional underground room-and-pillar mining (Figure IV-5). This mine will produce about 21.7 million tons of oil shale per year. This production will equal the demand of the proposed 66,000-ton-per-day processing plant, assuming that the plant would operate at approximately 90% capacity on a yearly basis. Within the scope of this mining plan, no recovery of nahcolite or dawsonite is contemplated; as noted above, only minor amounts of these minerals are present in the several alternative Mahogany zone mining intervals.

Mine access is planned to be via two 30-foot diameter vertical shafts, located as shown in Figure II-5. One shaft will be about 1450 feet deep, the second will be about 1650 feet deep. Limited parking, a mine office, change house, mine electrical substation and mine water and fuel supplies will be located on the surface in the 25-acre mine surface facility as shown in Figure IV-6. The primary crusher and equipment service stations will be located within the mine.

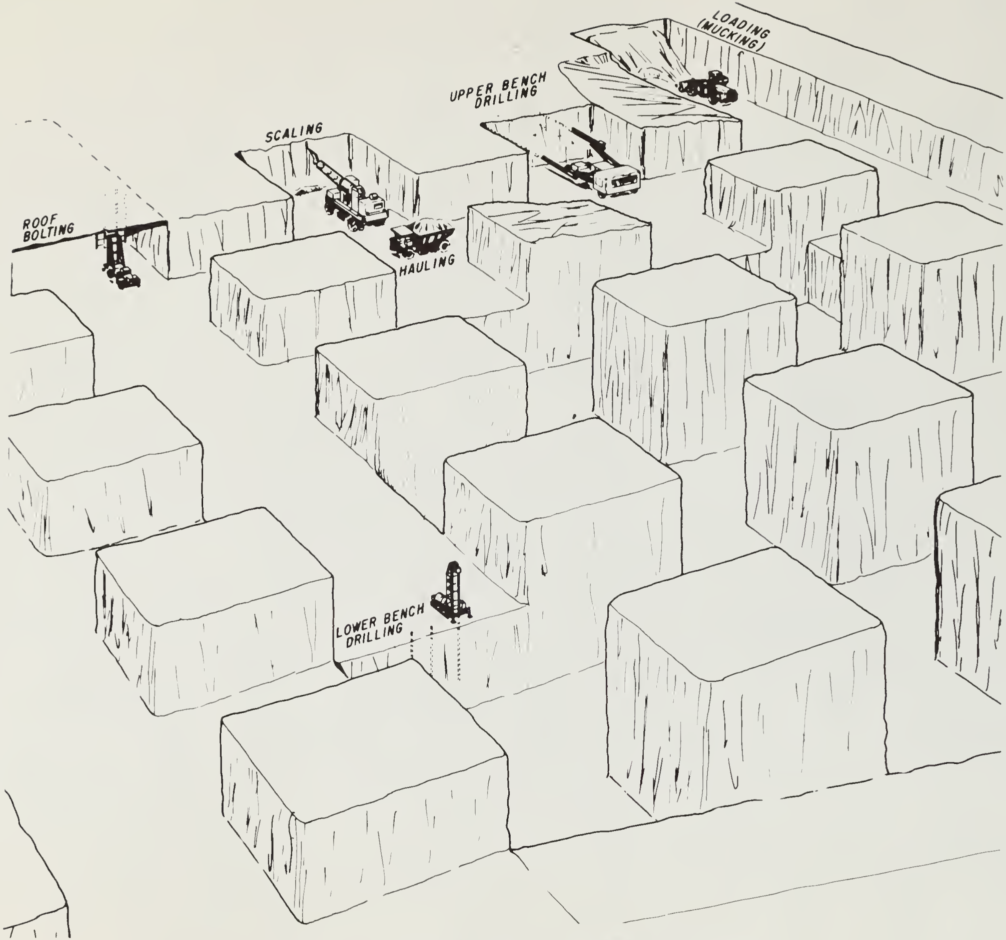


Figure IV–5 ROOM-AND-PILLAR MINING CONCEPT

A generalized, overall view of the underground mine layout for the Tract is shown in Figure IV-4. It should be noted that this is a preliminary projection of the commercial mine concept, and is subject to modification as further geotechnical data is obtained from development mining. The planned sequences of upper-bench and lower-bench mining are shown in Figures IV-7 and IV-8, respectively. The time intervals chosen correspond to those used in the discussion of the growth of the processed-shale pile in Section V. H., Processed-shale Disposal.

The mine layout shown in Figures IV-4, -7 and -8 does not envision mining of the pillar under the surface plant. Further studies may indicate the feasibility of partial extraction of this pillar.

One of the factors the mine design has taken into consideration is a balance between the effects of subsidence and recovery. Rock mechanics studies from other projects indicate that, for a range of overburden depths of 1000 to 1300 feet, extraction over 50% may result in subsidence. The long-term liklihood of subsidence is not well known at the present time because there is no large-scale experience available. Planned subsidence is often used to increase recovery factors and the possibility will be studied as part of the mine development work. Final design cannot be known prior to completion of that work. Whether subsidence will result in surface effects is dependent upon a number of factors, including mine depth, rock strength and failure characteristics.

Two natural processes will combine to counteract subsidence. The first is an arching phenomenon whereby the rock tends to bridge over and preserve the mined-out opening. The second involves rock's natural increase in volume when broken up into smaller pieces, due to the small voids created by the rock's inability to fit together exactly as before. This is sometimes called bulking. Should mine subsidence occur, the overburden will break, expand and tend to fill the mined-out void. The point of equilibrium should be reached beneath the surface and no surface collapses should occur.

One of the considerations included in analyzing subsidence is the possible effects on the aquifer systems overlying the mine zone. Any mine plan will evaluate this possibility.

3. Mining Cycle

Mining will proceed by the conventional room-and-pillar mining cycle of drilling, charging the drilled face or bench, blasting, wetting the blasted rock pile, loading, hauling, scaling and roof bolting. Roof bolting will only be necessary in the upper-bench cycle. These cycles are depicted in Figure IV-5. All portions of the cycle will be occurring simultaneously in various areas of the mine except for blasting. Blasting will occur during shift changes, at which time no personnel will be in the immediate area of the blast or fumes produced by the blast.

GRAPHIC SCALE

Figure IV–6

PHASE III MINE SURFACE FACILITIES PLOT PLAN

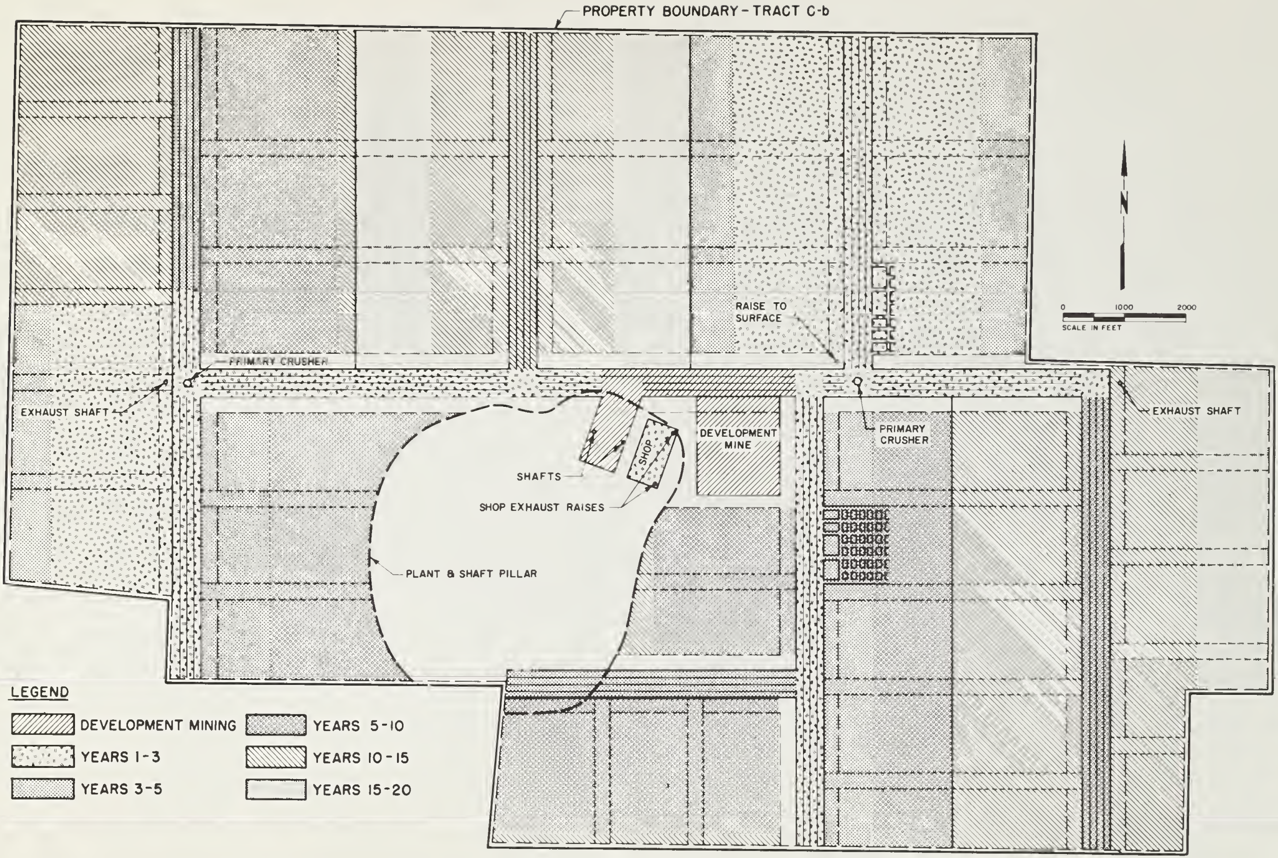


Figure IV—7 UPPER BENCH MINING ADVANCE

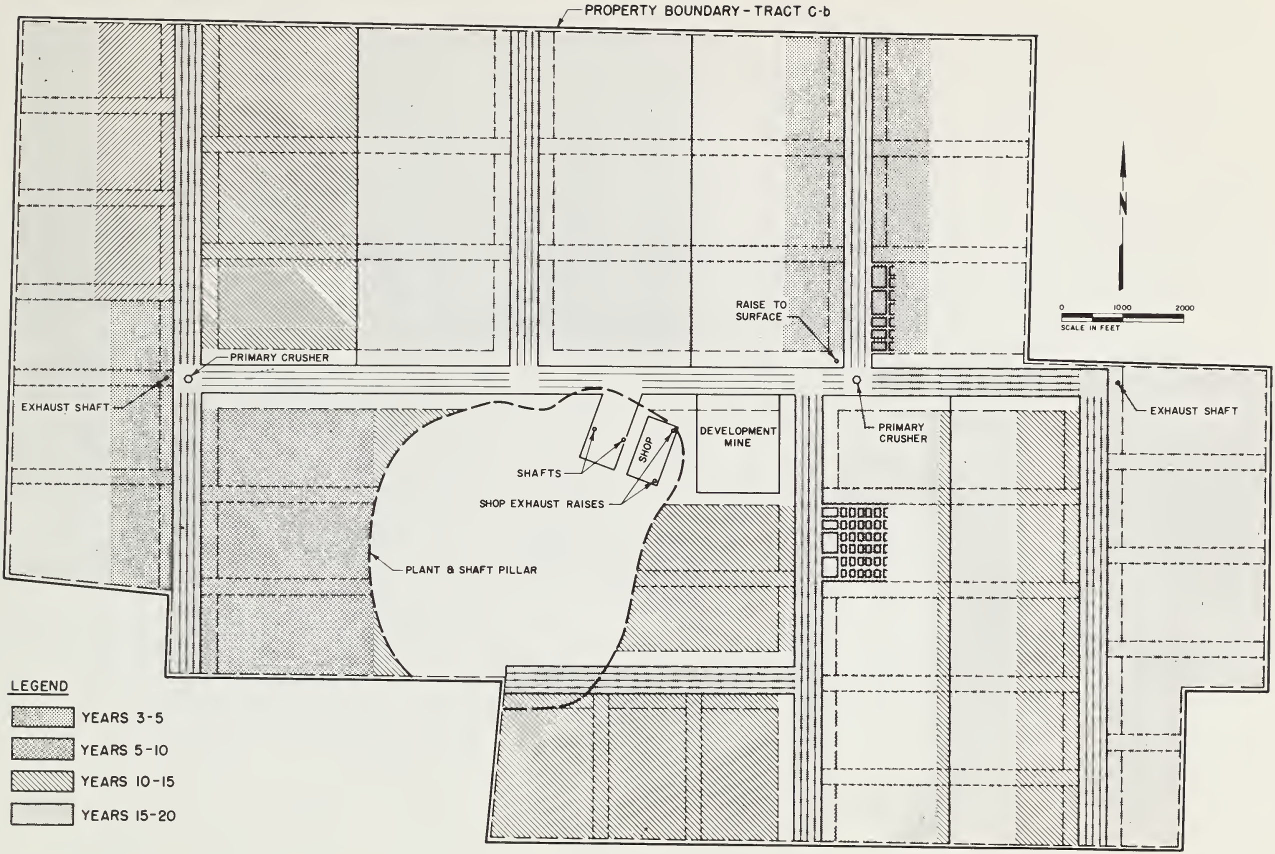


Figure IV–8 LOWER BENCH MINING ADVANCE

The first step in the mining cycle consists of drilling holes for placement of explosives. This operation will be performed with large-scale, diesel-powered, hydraulic rotary drills which produce substantially less noise and dust than percussion drills commonly used in underground mines. Water and wetting agents, if required, will be applied at the drill bit for additional dust control. The effect of noise on operating personnel will be minimized through use of sound-insulating cabs on the equipment and muffling of diesel engines where required.

Upon completion of the drilling phase, the holes will be loaded with an ammonium nitrate-fuel oil (ANFO) explosive mixture. Detonation will be initiated by a cap-sensitive explosive primed with a blasting cap. Detonation of this explosive, as with all such conventional explosives, produces quantities of carbon monoxide and nitrogen oxides. Properly mixed explosives and a controlled procedure for placement and detonation of explosives in the holes will substantially reduce production of these blast fumes. The explosion produces large quantities of dust in addition to blast fumes. Some of this dust will settle on the rock pile and the sides of the mine. The remainder will be carried away by the ventilation air which will be circulated through the blast area to reduce blast fume concentrations to safe levels before personnel will be allowed to enter the area. All personnel will be located at safe distances from the blast so that they will not be exposed to excess noise levels, air blasts, flying rock or other safety hazards.

The blast will produce a pile of broken rock weighing several thousand tons. The pile will then be wetted to minimize dusting. The pile will also be periodically wetted during the loading operation. This wetting operation is one of the major consumptive uses of water in the mining operation. Wetting agents will be utilized if they prove effective in reducing water requirements or improving dust suppression. The amount of water used to suppress the dust will be carefully regulated to minimize runoff from the pile of broken rock. The broken rock will be loaded into open-end dump trucks by large-capacity front-end loaders. These loaders and trucks are similar to equipment used in open-pit mining, but will be modified for underground use. In spite of previous wetting of the rock pile, some dust will be introduced into the mine area by this operation. Ventilation will be designed to keep dust concentrations within safe levels. If necessary, the equipment will utilize pressurized cabs to comply with health and safety standards. The oil shale will be trucked from the work area to the primary-crusher dump points at a rate of about one truck every 90 seconds on a 24-hour-per-day basis. Dust control measures will be used to minimize dust generated from the heavy truck traffic. These measures will include continuous road maintenance using conventional road wetting and chemical stabilizing techniques.

Present plans call for one-way traffic in the main haulage ways to and from the crusher dumping stations. Transportation of men and materials will be through service drifts parallel to the main haulageways in order to separate men and materials from the large trucks using the haulageways.

Haulage traffic will be controlled by a dispatcher and a series of traffic directional lights in the haulage mains.

After the rock pile has been removed from the work area, loose rock will be removed from the sides and roof of the mine by mechanical scaling equipment. This operation will dislodge dust resting on the sides and floor and reintroduce it to the ventilation air stream. If necessary, the sides and floor will be wetted to control dust to within safe limits. The scaling equipment may also require the use of pressurized, sound-insulated cabs.

Once loose rock is scaled down and removed, rock bolts will be installed in the mine roof to reinforce the roof. This operation requires drilling small-diameter holes some distance vertically into the roof and installing the bolt. Dust produced during the drilling operation will be controlled through the use of water at the drill bit or by vacuum collection and bagging systems operated through the hollow drill. The roof-bolting cycle will not be required for the lower-bench cycle. After roof bolting in the upper-bench cycle and scaling in the lower-bench cycle are completed, the mining cycle starts over with the drilling.

4. Mining Equipment

Selection of mining equipment for the commercial mine will be based on the specifications derived from the development mining activities and the equipment envelope developed from the finalized room-and-pillar dimensions determined by geotechnical studies. Most of the equipment selected for the commercial operation will be standard units commonly employed in the mining or construction industries. Specialized equipment such as rock drills, roof bolters and explosive loaders will be units of proven concept designed specifically for application to the finalized room-and-pillar dimensions. All mobile equipment will be diesel powered and equipped with catalytic exhaust systems to reduce emissions of hydrocarbons and carbon monoxide.

All mobile equipment that uses compressed air or water will be self-contained units with integral air compressors and/or water tanks. This will eliminate the need for extensive lengths of compressed air and water lines and will make the equipment highly mobile so that the required high production tonnage rates can be achieved.

Although the exact sizes and specifications for the commercial mining equipment will not be known until the completion of the development mining activity and the geotechnical studies, Table IV-3 lists the equipment types that might be used based on present information.

5. Mine Dewatering

The purpose of mine dewatering is to minimize operational, safety and stability problems caused by inflows of water into the mine. The

Table IV–3 DESCRIPTION OF COMMERCIAL MINING EQUIPMENT

	Item	Description
1)	Haulage Trucks	End dump rock trucks, 30 to 100 ton.
2)	Face Drills	Large, self propelled 2 to 4 boom jumbo with 15 to 30 foot booms.
3)	Down Hole Bench Drills	Standard self-propelled, open-pit down hole drill.
4)	Front End Loader	Bucket capacity of 5 to 15 cubic yards.
5)	Scaler	Standard backhoe with scaling pick mounted on end of boom arm.
6)	Roof Bolter	Self-propelled, two-boom roof bolt drill with personnel platform.
7)	Explosive Loader	Self-propelled explosive-charging machine.
8)	Explosive Trucks	Trailer mounted explosive magazines.
9)	Haul Road Maintenance Equipment	Grader and water trucks.
10)	Field Mechanics and Supervisory Vehicles	Diesel powered pickups, 3/4 ton.

ground water system below the Tract is still under intensive study, and definitive information concerning the magnitude and nature of the ground water problem will be determined by the development mining program. It will possibly be necessary to relieve ground water pressures from above the mine roof to insure roof stability. This could constitute the major source of ground water inflow. Additional water inflows could come from other areas such as the mine floor and mine shafts.

Based on preliminary hydrological data, mine water inflows do not appear to be excessive. If necessary, relief of pressure above the mine roof can be achieved by wells drilled down from the surface, by wells drilled up from the mine or by a combination of both. Water collected in the mine will be carried by pipe or ditch to a sump or settling basin where suspended solids will be allowed to settle out. The water will be used or pumped out of the mine. The mine dewatering system is shown in Figure IV-9. For a description of water storage and disposal systems, see Section II.

6. Mine Water Requirements

Mine water requirements are estimated to be approximately 1 CFS, or about 450 GPM. About 350 GPM of untreated mine water will be used for road wetting and muckpile dust control. About 100 GPM of treated mine water will be required for dust control spray systems, as well as in other uses.

7. Excess Mine Water

Excess mine water pumped to the surface will be stored in surface reservoirs and used in project operations. A certain portion of poor quality water can be used for surface requirements such as dust control and moisturizing of processed shale. These requirements can be met by mine water without further treatment. A major portion of the water requirements on the surface must be met by "clean" water. This would require surface treatment of mine waste water to remove the high dissolved-solids content. Presently, excess mine water is expected to be the major source of "clean" water for surface operations.

8. Ventilation

A preliminary ventilation plan is based on a parallel system of intake and exhaust airways designed to provide a once-through air course with a minimum of recirculation. The production and service shafts will be equipped so that both can serve as intake shafts, with two or more ventilation shafts located at opposite ends (east and west) of the Tract serving as exhaust shafts, as shown in Figure IV-10. Additional intake shafts will probably also be required in the vicinity of the production and service shafts. Service mains will be used as intake airways and haulage mains as exhaust airways. Air from conveyor drifts, crusher

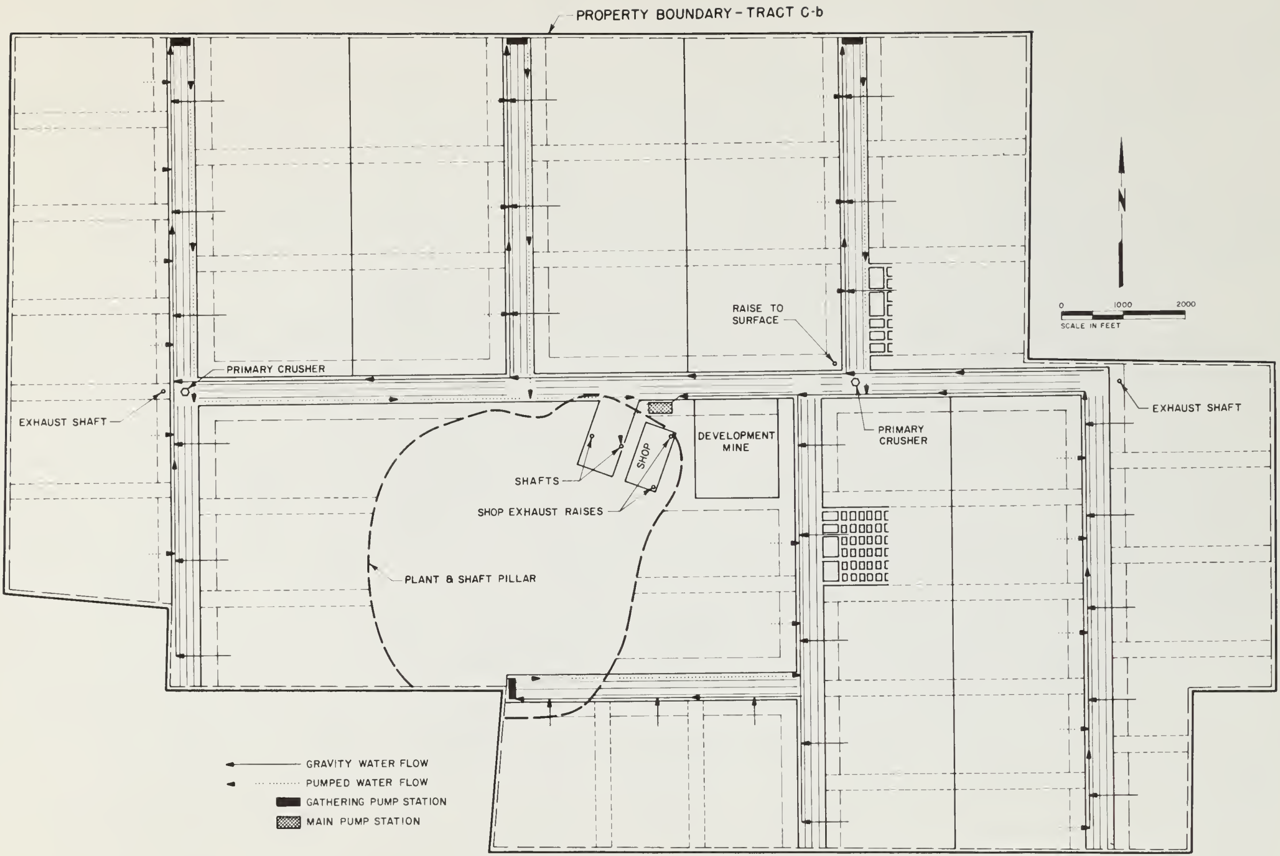


Figure IV–9 MINE DEWATERING PLAN

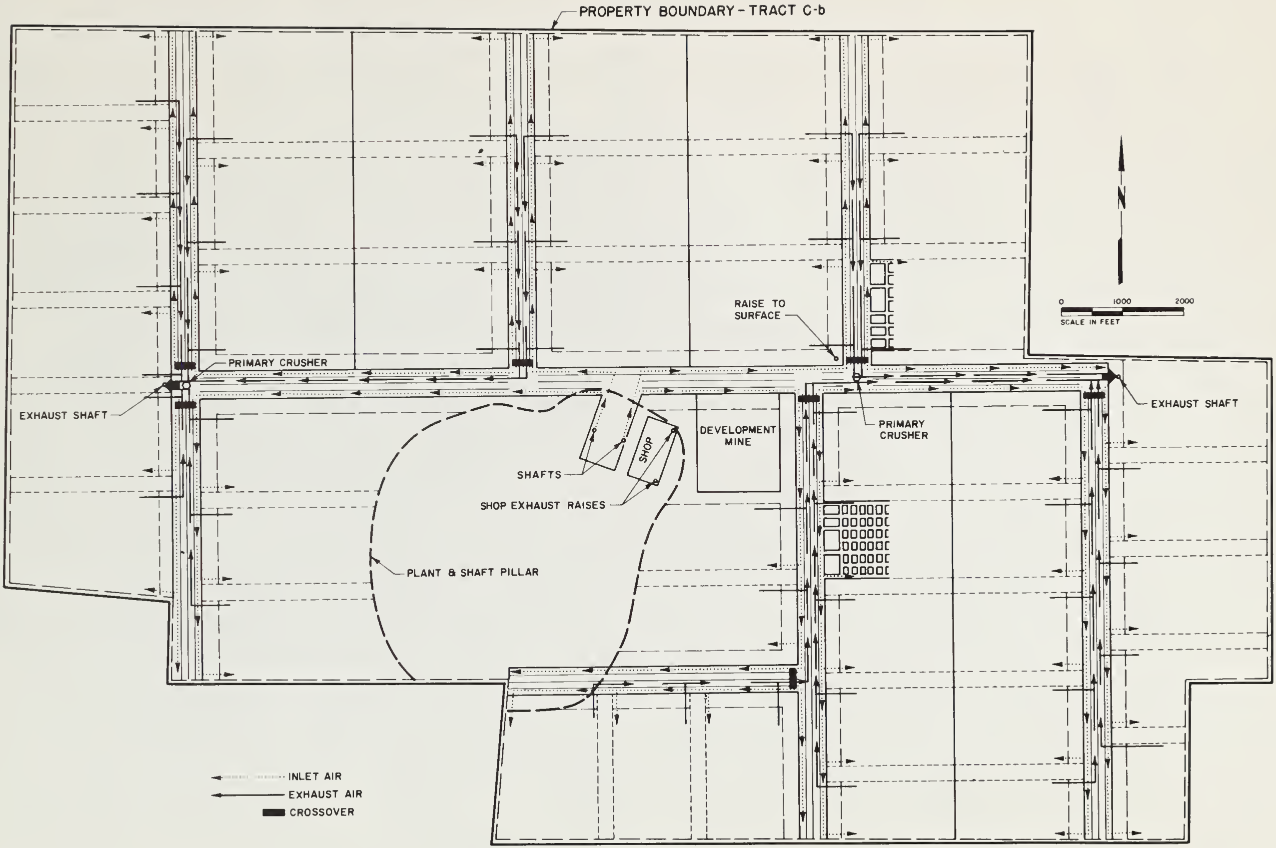


Figure IV—10 MINE VENTILATION PLAN

stations and the shop area will exhaust directly to the surface through small separate ventilation raises.

Air flow will be generated by primary exhaust fans which will be installed on the surface at the exhaust shafts. Primary ventilation volumes will range from a minimum of 4,000,000 cubic feet per minute (CFM) to a maximum of 8,000,000 CFM over the life of the mine. Primary fans will be controlled and monitored from remote control stations. Secondary panel ventilation will be provided by smaller underground fans. The ventilation system will clear the mine of blast fumes, dust, and diesel exhaust fumes generated by mobile mine equipment which are not removed by catalytic scrubbers mounted on the equipment. Air circulation will be controlled by the use of air curtains, brattices, overpasses, air doors and auxiliary fans in the mine.

Cleared and graded surface areas will be required for sinking and operating the ventilation shafts. The estimated land area required for each primary surface ventilation installation is about 300 feet by 300 feet, or about two acres. Although the commercial-mine ventilation design has not been completed, two primary exhaust ventilation shafts about 30 feet in diameter are planned. The estimated length of time required to develop the underground entries to the proposed locations (Figure IV-10) is about 19 months. After the entries have been driven, the primary ventilation shafts will be installed. Roads and surface-area preparation will be required prior to shaft boring.

An alternate to this plan would be to install only one primary ventilation shaft initially, with the other primary ventilation shaft installation deferred to a later period of the mine life.

The final mine design may also include the possibility of sinking auxiliary ventilation shafts for development and panel mining cycles. These auxiliary shafts would be about 4 feet to 12 feet in diameter. The locations of these shafts would be along the main entries and in the individual panels. Surface disturbance for this alternative would be about 200 feet by 200 feet, or about one acre per auxiliary shaft.

9. Underground Services

Maintenance Shop and Warehouse. The majority of mining equipment maintenance will be conducted in an underground maintenance facility. The underground maintenance shop will include provisions for overhead crane service, cutting and welding, hydraulic presses, lifts, lathes, drill presses, mills and other equipment necessary to assemble and maintain all the mining equipment and associated components required for mining operations.

Concrete floors will be poured in the maintenance area. Ground control procedures will be intensified in this area, utilizing additional roof bolting, roof mats, chain link fencing and sprayed concrete as needed to insure integrity of the maintenance facility for the entire mine life. The walls of the shop area will be sprayed with a light reflective coating and high intensity lighting levels will be maintained in the facility for safety and efficiency.

Ventilation air will be provided to the maintenance facilities in sufficient quantities to maintain safe and healthful working conditions. Exhaust hoods and ducting in individual service bays will remove localized concentrations of contaminants before they enter the main air flow in the shop. Exhaust ventilation will be direct from the shop to an exhaust shaft without traversing other working areas. Included in the design for the underground maintenance facilities is a central underground warehouse facility servicing the requirements of maintenance and mine production.

The maintenance and warehouse complex will be located within the bounds of the plant/shaft pillar, in close proximity to the service shaft for efficient materials transfer. Trouble shooting and minor repairs will be done from mobile maintenance vehicles or in temporary shops of limited capabilities located adjacent to active production areas.

Service Station. The daily requirements for fuel, lubricants and cooling-system fluid additions, and the regular service of lubrication and filter changes will be accommodated by a facility specifically designed for efficient servicing. This will assure coverage of the fleet requirements with minimum down-time. A central servicing facility will be established to maintain the majority of the mobile diesel fleet. The mobile diesel units will be equipped with centrally located service panels with connections for all service requirements arranged for ground-level access. Fast-fill, dry-break connections will allow for minimum service time, automatic shut-off, and elimination of spills due to overfill from personnel inattention or leakage during coupling operations. Distinctly different couplings will be utilized for each service requirement to avoid the possibility of misapplication.

All units will be equipped for fast lube change. All lubricant reservoirs will be evacuated directly through hose connections to sealed oil storage facilities, eliminating the need for open draining of reservoirs and the accompanying potential for spills.

Low-mobility equipment such as drill jumbos and roofbolters will be equipped with similar service connections and will be serviced in designated areas near the production areas by a mobile service van.

All elements of the servicing function will be designed to minimize the potential for fire. Dry-type extinguisher protection will be provided on all vehicles and in all work locations. In addition, high-density foam and/or dry-type fire extinguishing systems with both manual and automatic activation capabilities, will be used as appropriate.

Service station facilities will be located in an area which will have minimum traffic and designed so that air leaving the facility is not directed through other working areas.

Underground Waste Disposal. Underground sanitary facilities will be provided for the employees. The shop areas will have facilities included in the office, shop and store room complex. Portable field units will be located near the active working panels and crushing stations. The sewage from all of these locations will be pumped into a holding tank. This holding tank will be transported to the surface and discharged into a surface sewage treatment plant. The sanitary waste disposal system will be designed to meet all applicable federal and state regulations and the Stipulations.

Liquid petroleum wastes from the mining and maintenance operations will be collected and stored in holding tanks. These tanks will then be transported to the surface via the service shaft and then to the upgrading section of the plant for re-refining. If this is not economical, the wastes will be transferred to a waste petroleum dealer for disposition.

Underground solid waste and garbage will be transported to the surface for disposal. Disposal will be in the processed-shale pile or in a sanitary landfill. Solid waste disposal is discussed in more detail in Section V. I., Disposal of Other Wastes.

10. Utilities and Fuel

Electric Power. The underground power distribution system will provide power at the required voltages for all underground systems and facilities. Plans call for the power to be run underground at 13,800 volts to an underground primary transformer station. At this station, the voltage will be reduced to 4160 volts for distribution. Underground transformers will be located where required to reduce the voltage from 4160 to the required levels for use. The power distribution system will be designed, installed and maintained in such a manner as to afford the greatest safety, reliability and flexibility. The system design and hardware components will meet all applicable federal and state regulations for underground non-metallic mines. A summary of the power requirements for the commercial mine is given in Table IV-4.

Fuel. The operation of the mobile equipment fleet at the planned commercial level will require the transfer to and distribution within the mine of approximately 15,000 gallons of No. 1 diesel fuel daily. The volume requirement and limited mine access precludes efficient transfer of fuel to the mine by tank truck via the service cage.

A safe, simple and efficient system is planned for the routine and scheduled transfer of fuel from surface storage tanks to the underground distribution system. Fuel will be drawn from surface storage, by

Table IV–4 POWER REQUIREMENTS DURING COMMERCIAL MINING

	Horsepower	Load, KVA
General Services (Includes surface and underground facilities)		5,000
Hoists	21,500	16,600
Underground Crushers and Conveyors	5,500	4,200
Ventilation	13,000	10,000
Pumping	30,000	24,200
Totals	70,000	60,000

pipeline, into a surface measuring tank. An interlocking valve system will isolate the main storage tanks from the measuring tank before fuel can be released. Fuel discharged from the measuring tank, at a controlled rate, will flow by gravity through a welded steel pipeline to a receiving tank at the service station within the mining horizon, either through an exhaust shaft or borehole specifically drilled for this purpose. The receiving tank at the bottom of the fuel line will exceed the capacity of the measuring tank on surface by 100% to insure sufficient capacity for all fuel dispatched. The fuel system will be properly vented to the atmosphere. Fuel will be dispatched in batches and, during fuel transfer operations, constant, mandatory telephone communication will be maintained between responsible employees at the measuring tank and the receiving tank. Transfer of fuel from the surface will take place only when adequate capacity exists in underground storage tanks to accept the measuring tank's capacity. The pipeline and measuring tank will contain no fuel except during attended fuel transfer operations. Control features of the system will be designed so that malfunctions will prevent operation and so that the chance of spills will be virtually eliminated.

Fuel storage underground will be limited to a maximum quantity of one day's supply. Storage and distribution will be in compliance with all federal, state and local regulations and dispatch of fuel to the underground storage will be conducted on schedule under the direct supervision of a responsible employee.

Potable Water. Drinking water for mine employees will be piped underground from the surface water treatment facilities to the underground maintenance shops. The facility will be served by appropriately located industrial drinking fountains. Potable water for the employees working in production areas or other areas remote from the shop facilities will be supplied in insulated, dispensing containers and will be replaced once per shift by assigned personnel. One-use drink cups will be maintained at all supplies of potable water and suitable disposal containers will be appropriately located.

Lighting. High intensity lighting will be located in and on all surface structures, shaft stations, shop facilities, dumping and crushing facilities and around electrical transformer and switch stations, walkways, stairways and office facilities. Low intensity lighting will be located in the main haulageways with suitable low to high intensity transition areas immediately adjacent to high intensity lighting areas. Active working areas will be illuminated by lights on each piece of mobile mining equipment. All personnel underground will have personal cap lamps of an approved type to supplement the lighting facilities included in the mine and on the mining equipment.

The lights and lighting in the mine will be designed and installed in such a manner as to meet or exceed all applicable federal and state regulations and the Lease requirements.

Communications. There are three types of communications systems that could be employed in the commercial mine. They are a hard-wired telephone network; a combination of a hard-wired network and a radio network; and a total radio network.

The primary communications system for the mine will probably consist of a telephone network with extensions located at primary work areas such as the crusher stations, shaft stations, shop, emergency facilities, storeroom and offices. This system would be tied into the surface telephone network via telephone lines in the shaft.

Investigations are underway to determine the feasibility of a low-frequency multi-channel radio system for underground communications. Preliminary results indicate that a five-channel system would be most efficient. The five channels are defined as: 1) two-way communications between mining equipment operators and the dispatcher; 2) two-way communications between haulage equipment operators and the dispatcher; 3) a two-way supervisory communications channel which could monitor all channels as well as provide communications between supervisors; 4) a mine monitoring and alarm channel for detection of air quality and other hazards; and 5) an emergency alert channel.

D. Crushing and Conveying

The purpose of crushing and conveying operations is to reduce run-of-mine rock to retort feed size and to provide a continuous flow of material to the retort while allowing efficient conduct of mining activities. To accomplish this task a system of crushing, conveying and intermediate storage facilities will be used. This system will be electrically powered with an estimated power consumption of 150 million KWH annually. As presently envisioned, the crushing operation will be conducted in two stages, a primary crusher reducing rock from run-of-mine size to a nominal 8-inch to 12-inch product, and a secondary system reducing the 8-inch to 12-inch product to minus 1/2-inch retort feed.

Primary crushing will probably be performed underground to allow efficient transport of rock to the surface. One or more primary crushers will be located centrally with respect to mine haulage operations (see Figure IV-4). Rock will be hauled to the primary crusher and dumped into a small intermediate storage bin. Rock will move to the crusher either by gravity or by feeder. After primary crushing, the rock will be transported by conveyor to underground storage. This storage will be of sufficient capacity to allow efficient operation of the shaft hoisting equipment. The current estimate of total storage capacity underground is about 32,000 tons.

Primary crushed rock will be delivered from underground storage to skip-loading pockets, where it will be transferred to skips for hoisting to the surface (Figure II-7). At the surface the rock will be dumped into surface storage of sufficient capacity to allow a smooth interface with a surface belt conveyor. The belt conveyor will transport the rock to the coarse-ore stockpile. Present plans call for the use of a traveling stacker to build the coarse-ore stockpile, as shown in Figure IV-11. However, other methods including a stacker-reclaimer system and multiple stacking towers are currently being evaluated.

The coarse-ore stockpile is needed to balance the different operating schedules of the mine and retort, and to prevent shutdowns of one facility from impairing operations of the other. The coarse-ore stockpile will also be used for storage of rock produced during development mining and commercial mine development prior to plant start-up. Current indications are that the coarse-ore stockpile will be designed with a live operating capacity of 500,000 tons, and a total capacity of 2,000,000 tons.

The stockpile will occupy about 35 acres in the area of Cottonwood Gulch. During Phase II, this pile might contain in excess of 10,000,000 tons and occupy an area of 80 acres.

Overall system capacity will be based on the requirements of mining and retorting, and is estimated at 4400 tons per hour. In normal operation the secondary crushing plant will operate on the same schedule as the retort. During secondary crushing, material from the primary crusher will by-pass the coarse-ore stockpile (Figure IV-12) and travel directly to the secondary crushing plant, with all material in excess of plant needs continuing on to the coarse-ore stockpile. An alternative would be to have the total mine production enter the stockpile, in which case the reclaim rate from the coarse-ore stockpile would equal the plant feed rate and excess production would be retained in the stockpile. In either case, if mine production is less than retort requirements, the difference would be made up by reclaim from the stockpile.

Current plans envision a 10-unit parallel crushing system with impact crushers operating in closed circuit to reduce the nominal 8-inch to 12-inch secondary crusher feed to minus 1/2-inch retort feed (Figure IV-13). The secondary crushing plant will be located in close proximity to the retorting complex. Material transportation from secondary crushing to the retorts will be by belt conveyor, with a nominal 15,000-ton intermediate storage facility (Figure IV-14). This facility is needed to balance crushing and retorting schedules, and to provide emergency storage to minimize the impact of failures in the secondary crushing system on retort operation. System capacity of the secondary crushing plant would be on the order of 3000 to 3500 tons per hour.

Dust control for the rock handling systems will be achieved by a combination of dust suppression and dust collection systems. All surface conveyors and transfers will be covered to minimize dust generation under adverse conditions (Figures IV-15 and IV-16), and to assure

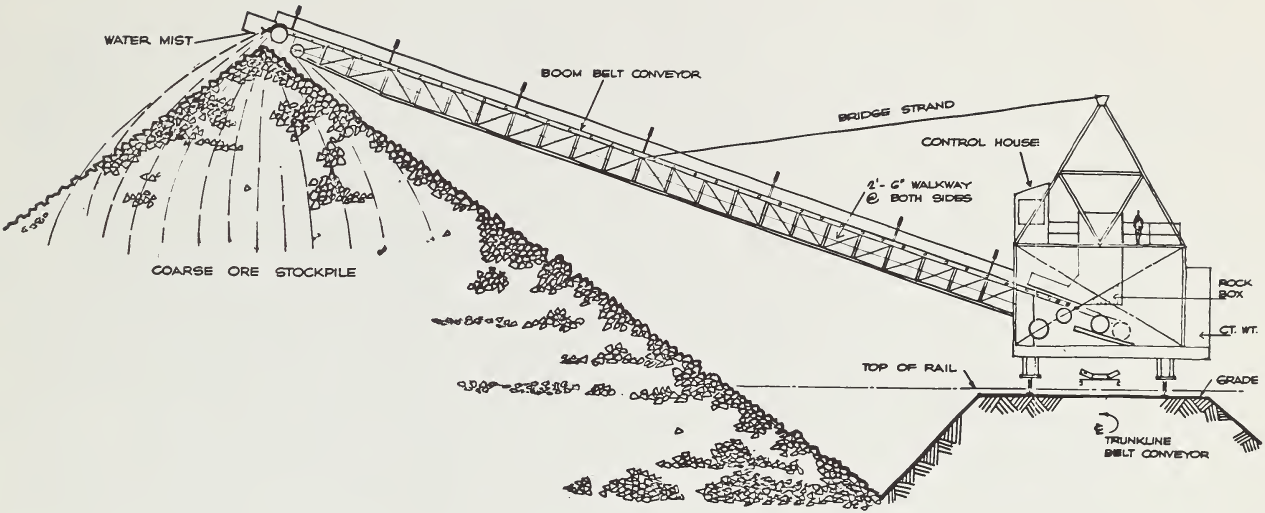


Figure IV–11 CONCEPTUAL DIAGRAM OF TRAVELING STACKER

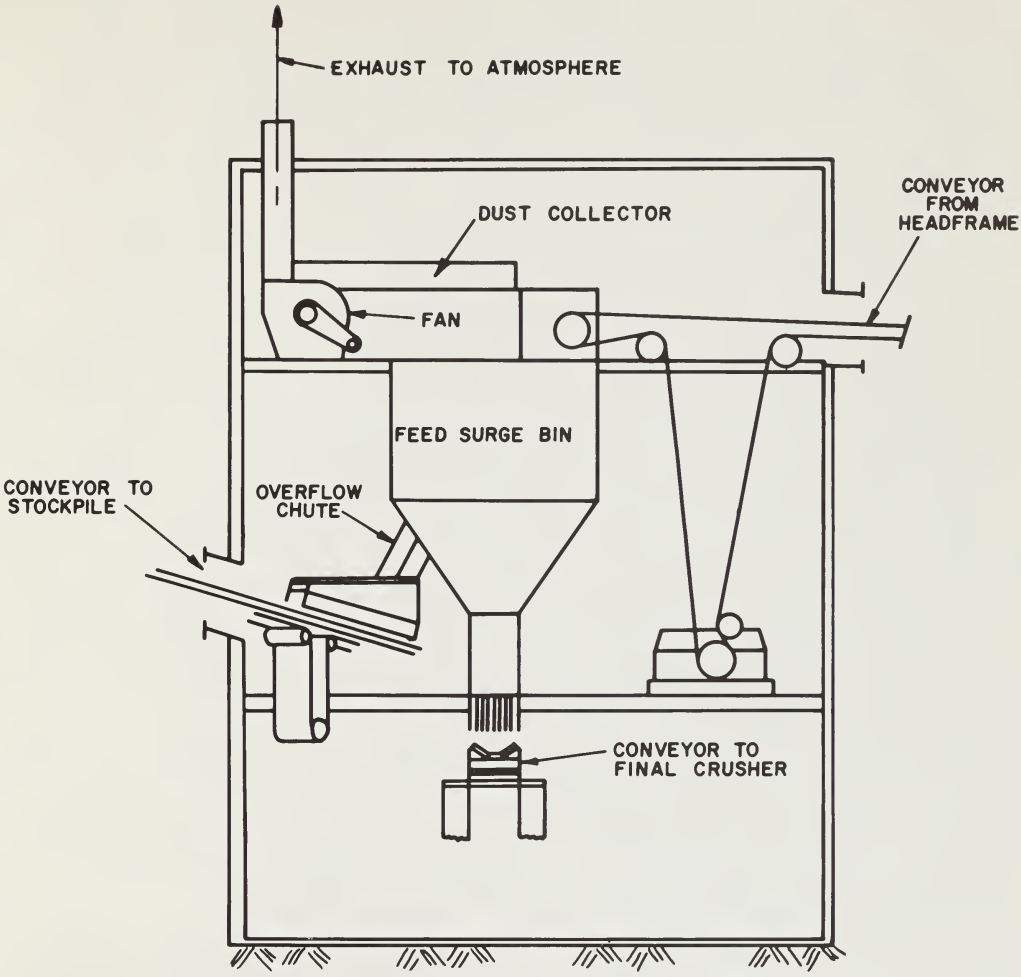


Figure IV—12 COARSE ORE BY-PASS

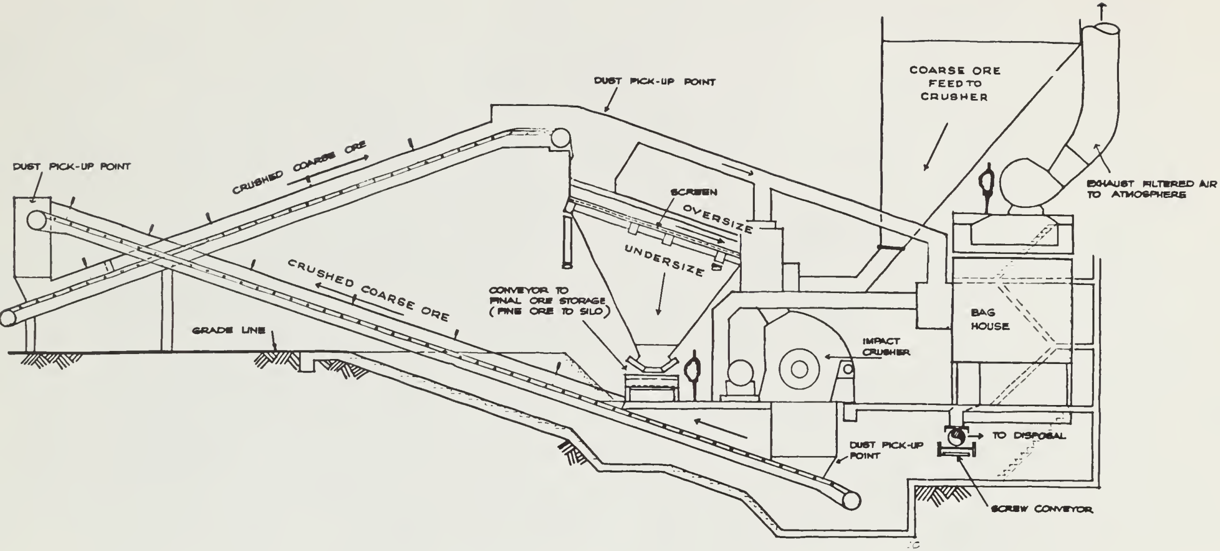


Figure IV–13 CONCEPTUAL DIAGRAM OF SECONDARY CRUSHER

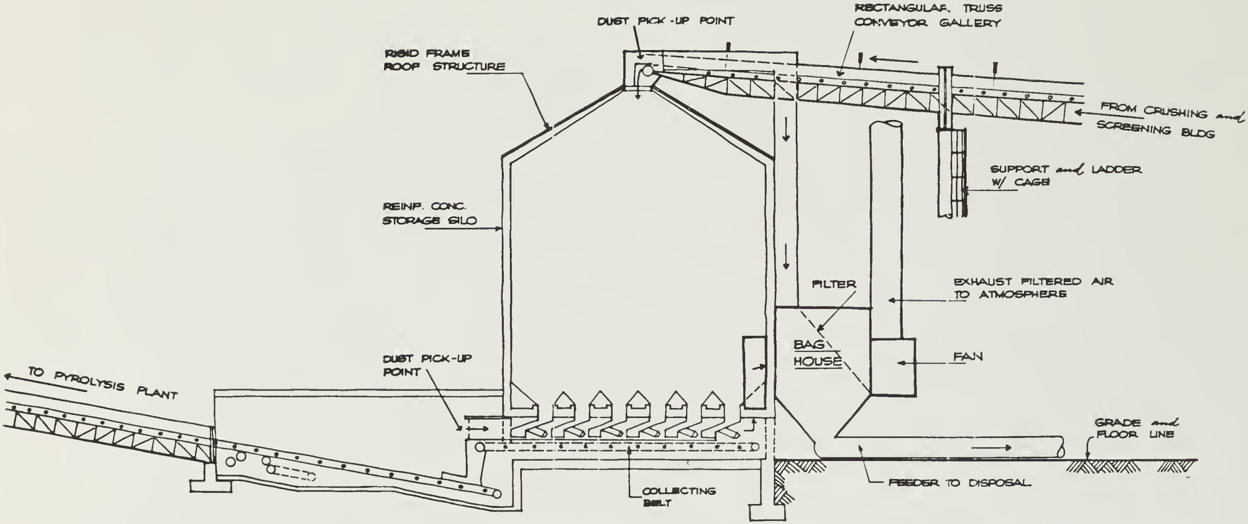
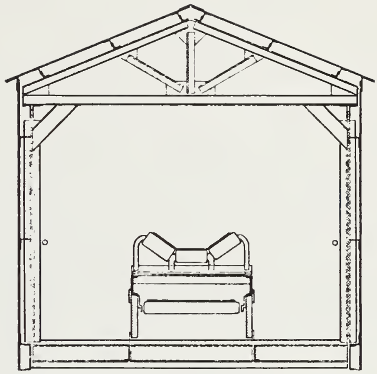
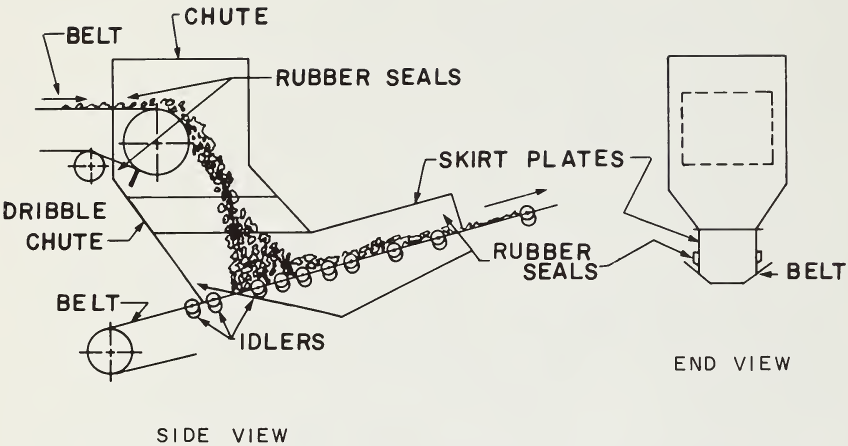


Figure IV–14 CONCEPTUAL DIAGRAM OF FINE ORE STORAGE



(Not to Scale)

Figure IV–15 TYPICAL ENCLOSED CONVEYOR



(Not to Scale)

Figure IV–16 TYPICAL ENCLOSED CONVEYOR TRANSFER POINT ease of operation in all weather conditions. System operations will be conducted from controlled-environment crusher control rooms to minimize operator exposure to dust and noise.

E. Retorting and Upgrading

The retorting and upgrading operations described in this section will convert 66,000 tons per stream day of crushed raw shale, averaging 35 gallons of oil per ton, into usable products and disposable wastes. The daily production includes 45,000 barrels of low-sulfur oil, 4200 barrels of liquified petroleum gas (LPG), 180 tons of sulfur, 140 tons of ammonia and 800 tons of coke. Fuels produced by the plant for internal consumption include treated high-BTU fuel gas, a C_4 liquid (containing butanes, butenes, and some C_3's), fuel oil and diesel fuel. The primary waste is processed shale.

As a design and planning basis for the Tract, the gas produced in the complex will be treated and used as a fuel in the retorting and upgrading units. Because of the sulfur and nitrogen content of crude shale oil, it is not readily marketable. The sulfur content is considered moderate when compared to conventional crude oils. However, the nitrogen content is considered to be relatively high. Consequently, this complex will contain, in addition to the pyrolysis and oil recovery units, hydrogenation facilities specifically adapted for processing shale oil in order to produce an oil product having reduced sulfur and nitrogen content. In addition, the upgrading process will reduce the pour point and viscosity of the oil to make it easier to transport by pipeline.

Although a hydrotreating scheme is planned for the oil upgrading facilities on the Tract, the degree of upgrading can range from simple fractionation to the production of finished fuels or premium refinery feedstocks. The choice of upgrading schemes depends primarily on economic and market conditions.

Two principal options are available in producing shale oil for market. One is to minimize upgrading and market the raw shale oil as a synthetic heavy crude oil or No. 6 fuel oil. The second option is to upgrade or refine the raw shale oil on the Tract. This would yield a product suitable for marketing as No. 2 fuel oil or suitable for direct conversion to finished products such as gasoline, turbine fuel, home heating oil and petrochemical feedstocks.

Each option has its own slate of by-products. Raw shale oil production could yield LPG, coke and small amounts of sulfur as by-products, while upgraded oil production could yield LPG, coke, larger quantities of sulfur, and ammonia.

The remainder of this section describes the retorting and upgrading facilities under the second option, i.e., on the basis that raw shale oil will be hydrotreated on-tract. This is the preferred upgrading scheme and therefore will be presented in some detail.

Raw shale oil has about 2% nitrogen and 0.7% sulfur and is high in unsaturated, unstable hydrocarbons. These properties make raw shale oil more difficult to handle as a fuel or refinery feedstock than conventional petroleum. Its high pour point and viscosity also create special requirements for pumping through a pipeline.

In addition to the retorting and upgrading units required for the production of a low-sulfur oil product, certain additional process units are designed to minimize overall plant complex environmental impacts. The units in this category are the gas recovery and treating unit, the sulfur recovery unit, the ammonia separation unit and the foul-water stripper unit. These units contribute to the production of sulfur and ammonia, which are marketable by-products. The need for these process units, however, is primarily an environmental rather than economic consideration.

In the following discussion, equipment has been grouped into process units. Equipment within a process unit may actually be located in several geographic locations within the plant boundaries. Process units in the retorting and upgrading section are: 1) Pyrolysis and Oil Recovery; 2) Gas Recovery and Treating; 3) Hydrogen Production; 4) Gas-oil Hydrogenation; 5) Naphtha Hydrogenation; 6) Ammonia Separation; 7) Sulfur Recovery; 8) Delayed Coker; 9) Foul-water Stripping; and 10) Tankage.

An artist's rendition of the shale oil complex including the retorting and upgrading units, is shown in Figure IV-17.

A block flow diagram showing the flow of material through the retorting and upgrading section is shown in Figure IV-18. These separate processing units, which involve many recycle and side-stream operations, process the crushed raw shale into oil, by-products and wastes.

The pyrolysis unit shown incorporates the TOSCO II oil shale retorting process. This process and its environmental impacts have been extensively studied in a 25 TPD pilot plant and a 1000 TPD semi-works plant. The TOSCO II process is the most thoroughly proven retorting technology available at the present time, and is used as a basis for present planning for development of the Tract. However, if improved retorting techniques become available on a timely basis, they will be considered. Environmental control procedures for the TOSCO II retorting method have been developed and proven during the pilot plant and semi-works plant operations, as well as by engineering and design studies.

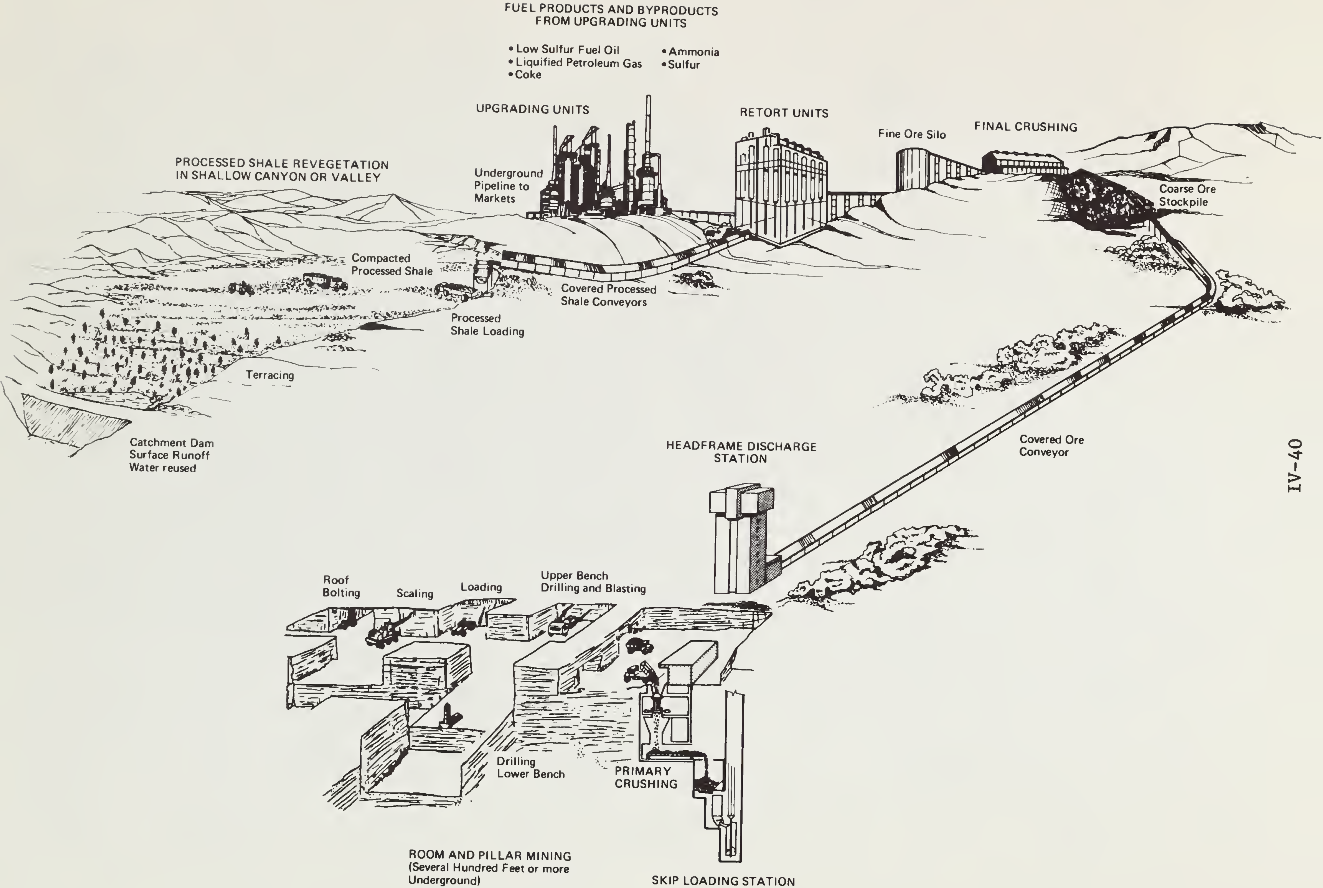


Figure IV–17 ARTIST'S RENDITION OF A SHALE OIL COMPLEX

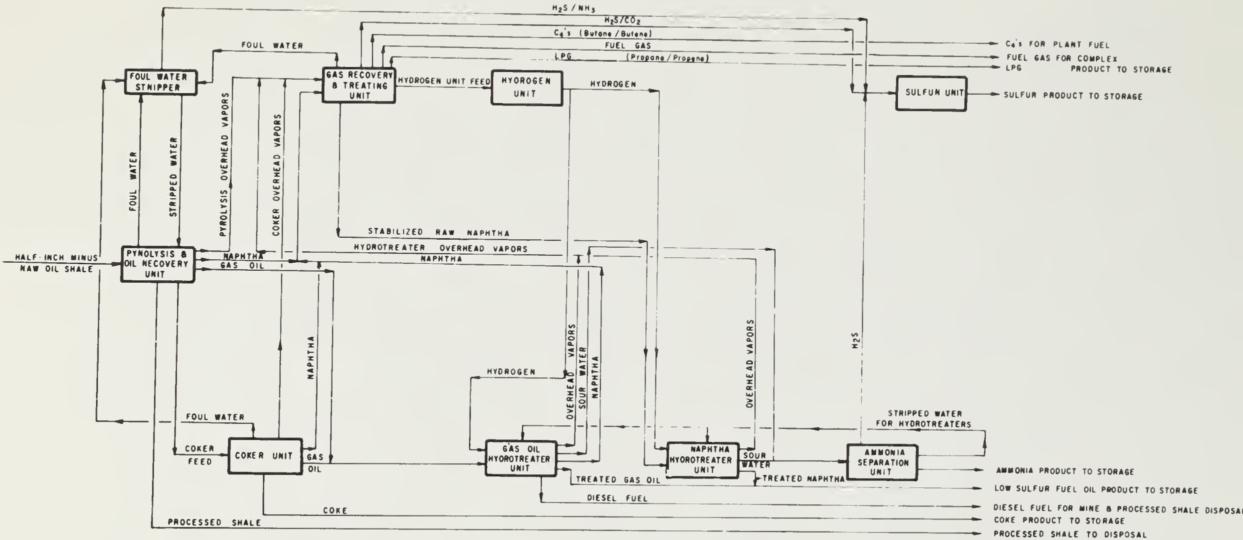


Figure IV–18 BLOCK FLOW DIAGRAM RETORTING AND UPGRADING UNITS

The upgrading units consist of modern refinery processes and equipment. Such processes have well-developed pollution control techniques. The combined pollution control technology developed from the experimental operation of the semi-works plant and from the operation of existing refineries will be used to minimize environmental impacts.

All of the fuel requirements for the plant complex will be supplied by gas, liquid C_4's, fuel oil and diesel fuel produced in the retorting section and treated in various upgrading units. In addition to the fuel system, units shown in Figure IV-18 will be serviced by a water system, steam system, an electrical distribution system, a compressed air and inert-gas system, and a flare system. These services are described more fully in Section IV. I.

1. Pyrolysis and Oil Recovery

This unit, which contains the oil shale retort vessels, converts the kerogen content of raw shale into hydrocarbon vapors and liquids. The hydrocarbons are separated by fractionation and sent to various upgrading units. The processed shale is transported from this unit to a disposal area.

The pyrolysis and oil recovery unit will consist of six individual "TOSCO II" retorting trains, each capable of processing 11,000 tons per day of raw shale. Figure IV-19 presents a schematic drawing of the pyrolysis and oil recovery unit.

The raw shale, which has been crushed to particles less than one-half inch in size, is conveyed from the fine-crushed-ore storage to the retort section and discharged into bins that feed the six trains. The raw shale is then fed to each of the retorting trains where it is preheated by direct heat exchange with hot flue gas from the ball heater. The flue gas is cooled during this heat exchange process. The preheated raw shale is separated from the flue gas in settling chambers and cyclones and sent to a rotating drum retort.

Hot flue gas is incinerated within the preheat system to reduce trace hydrocarbons to less than 90 parts per million (PPM) in the discharge flue gas. The cooled flue gas is passed through dry cyclones and a high-energy venturi wet scrubber to remove shale dust before being vented to the atmosphere at a temperature of approximately 125°F to 130°F. The scrubbers will produce an effluent stream of raw shale dust in water. This stream is sent to a clarifier, where a portion of the water is removed and recycled to the scrubbers. Thickened sludge produced in the clarifier will be placed on the processed-shale conveyor for disposal in the processed-shale embankment.

Pyrolysis is accomplished in the retort by solid-to-solid heat exchange between the preheated shale and hot ceramic balls. The balls

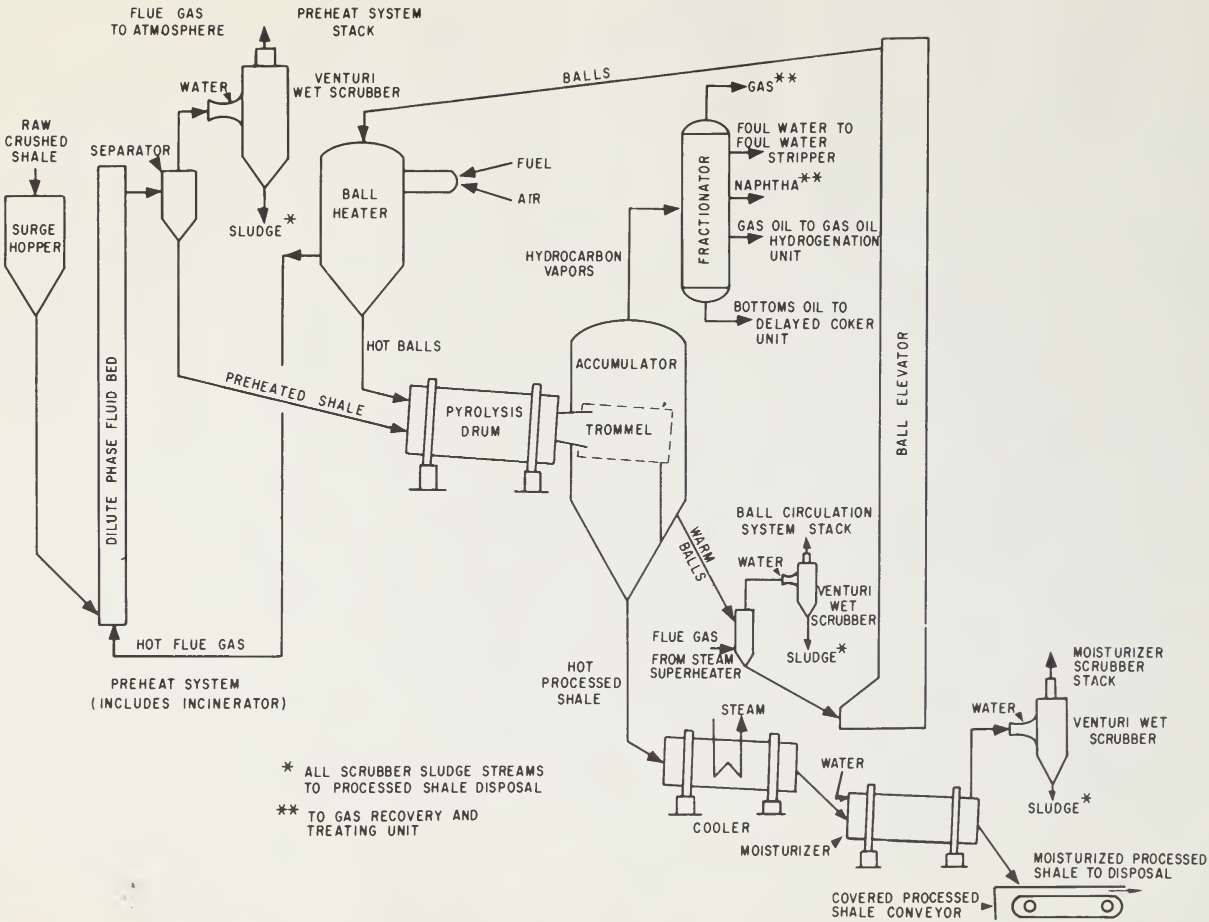


Figure IV–19 PYROLYSIS AND OIL RECOVERY UNIT
TOSCO II PROCESS

are heated in a vertical ball heater and then fed to the retort to mix with the preheated shale. The mixture of balls and shale flows through the retort, where the shale is pyrolyzed at a temperature of about 900°F. This results in the conversion of the kerogen in the shale to hydrocarbon vapors. These vapors are recovered in an oil recovery system, leaving a residual mixture of balls and processed shale. This mixture leaves the retort and passes over a rotating trommel screen which separates the balls from the processed shale.

Heated flue gas from the stack of a steam superheater will be used to entrain residual dust from the ball circulation system. The dust will be removed from the flue gas with cyclones and a high-energy venturi wet scrubber. The balls are then circulated back to the ball heater by means of a bucket elevator.

The processed shale is cooled in a rotating drum steam generator. The product steam enters the plant utility system. The cooled processed shale is moisturized to approximately 14 weight percent moisture in a rotating-drum moisturizer to minimize fugitive dust and insure proper handling and compaction characteristics. Wastewater will be used to moisten the processed shale. Processed water from the sewage treatment facility and from mine drainage, and impounded runoff from the processed-shale embankment will constitute wastewater sources. Steam and processed-shale dust produced in the moisturizing process are passed through a venturi wet scrubber to remove the dust before discharging the steam to the atmosphere. The moisturized processed shale is transported by covered conveyor to the processed-shale disposal site.

In the oil recovery section of this unit, hydrocarbon vapors are separated by fractionation into gas, naphtha, gas oil, bottoms oil and water. The gas and naphtha streams are sent to the gas recovery and treating unit for gas treating and naphtha stabilization. The gas oil is sent to the gas-oil hydrogenation unit. The bottoms oil is sent to the delayed-coker unit. Moisture in the gas stream is condensed and sent to the foul-water stripping unit which removes the absorbed ammonia and hydrogen sulfide. The stripped water is used in the pyrolysis unit for moisturizing processed shale.

Process heaters in the pyrolysis unit will be designed to burn either treated fuel gas, liquid C_4's, or fuel oil produced in the plant.

2. Gas Recovery And Treating

In the gas recovery and treating unit, gas and raw naphtha produced in the oil recovery, coker, naphtha hydrotreater and gas-oil hydrotreater units are separated into fuel gas, liquified petroleum gas (LPG), butanes and a stabilized naphtha. Hydrogen sulfide is removed from fuel gas, LPG and butanes as required for environmental and process considerations. Fuel gas is used as plant fuel and hydrogen plant feed.

LPG is a blend of propane and propylene and will be sold as a product. The butane stream is a mixture of butane and butylene and will be used as plant fuel. Stabilized naphtha is sent to the naphtha hydrotreater for further processing. Process operations in this unit include oil absorption, diethanolamine (DEA) contact, and amine regeneration. A schematic drawing of the unit is given in Figure IV-20.

Overhead vapors and raw naphtha from the oil recovery, coker, gas-oil hydrotreater and naphtha hydrotreater units enter the reboiler-absorber stripper where C_3 and heavier fractions are absorbed into a lean oil. Rich oil from the reboiler absorber stripper is fractionated to produce a C_3/C_4 gas stream and a stabilized raw naphtha for feed to the naphtha hydrotreater and for recycle to the absorber stripper as lean oil. The stabilization process removes the lighter hydrocarbon components from the naphtha, reducing the vapor pressure and producing a more stable liquid hydrocarbon. The overhead C_3/C_4 stream is contacted with a lean amine solution for removal of H_2S. Subsequently, the treated C_3/C_4 stream is split by fractionation. LPG is sent to storage for sales and the C_4's are used for plant fuel.

Overhead vapors from the lean oil absorber stripper, which consist primarily of ethane (C_2) and lighter gases, are contacted with a lean amine solution for H_2S and CO_2 removal before being used as fuel and hydrogen unit feed. The H_2S content of the fuel gas will be less than 10 grains/100 standard cubic feet (SCF), as currently required by the Environmental Protection Agency. The amine solution is regenerated by driving off H_2S and CO_2, which are sent to the sulfur unit.

Water vapor in the various overhead streams which feed the gas recovery and treating unit is condensed. The resulting condensate is sent to the foul-water stripper for removal of H_2S and ammonia.

3. Hydrogen Production

Hydrogen will be used in the hydrogenation units to remove nitrogen and sulfur from the naphtha and gas-oil streams.

Hydrogen is produced from fuel gas and steam in a conventional steam reforming process, as shown in the schematic flow diagram in Figure IV-21. The basic steps for the steam reforming process are desulfurization, reforming, carbon monoxide (CO) conversion, carbon dioxide (CO_2) removal and methanation. The desulfurization of the fuel gas will be a three-step process which removes essentially all traces of sulfur to protect downstream catalysts from sulfur poisoning. First, the fuel gas will pass through a hydrodesulfurization (HDS) catalyst to convert the bulk of the sulfur compounds to H_2S and saturate olefins. This catalyst will probably be cobalt molybdate. Second, most of the H_2S and unconverted sulfur compounds will be removed in an absorber which circulates a solvent selected for the particular sulfur compounds

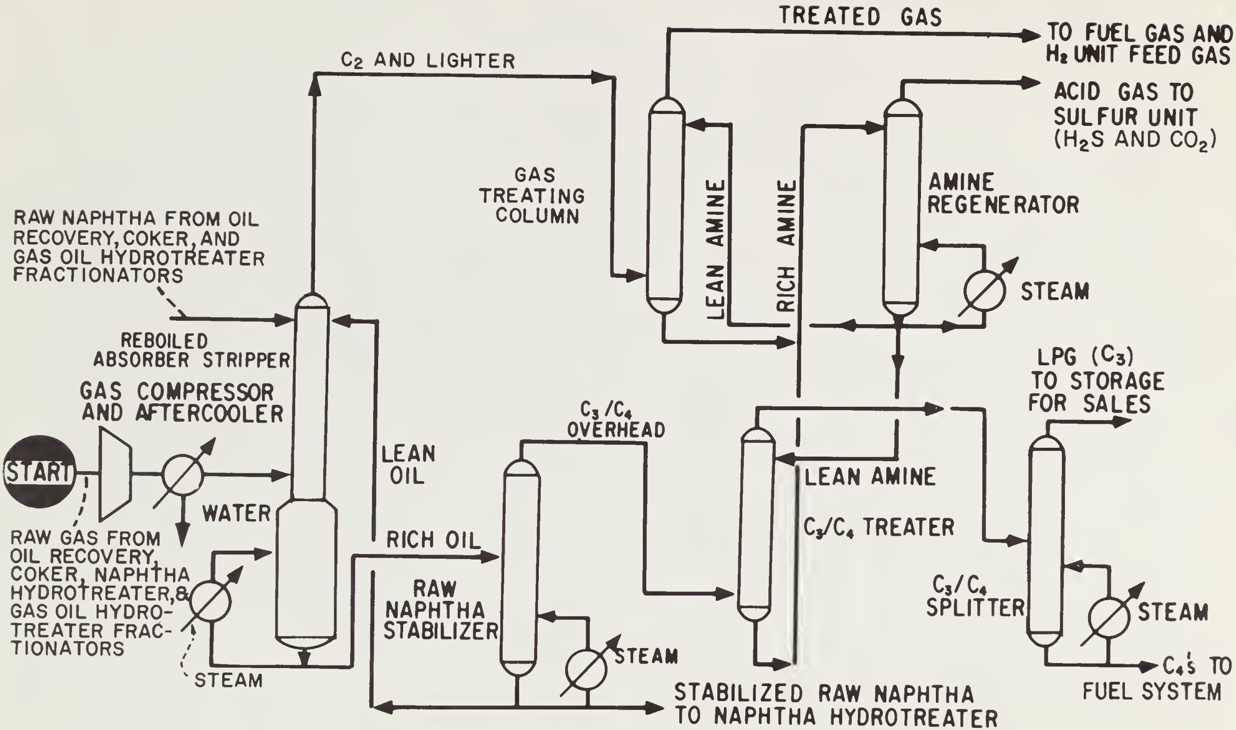


Figure IV—20 GAS RECOVERY AND TREATING UNIT

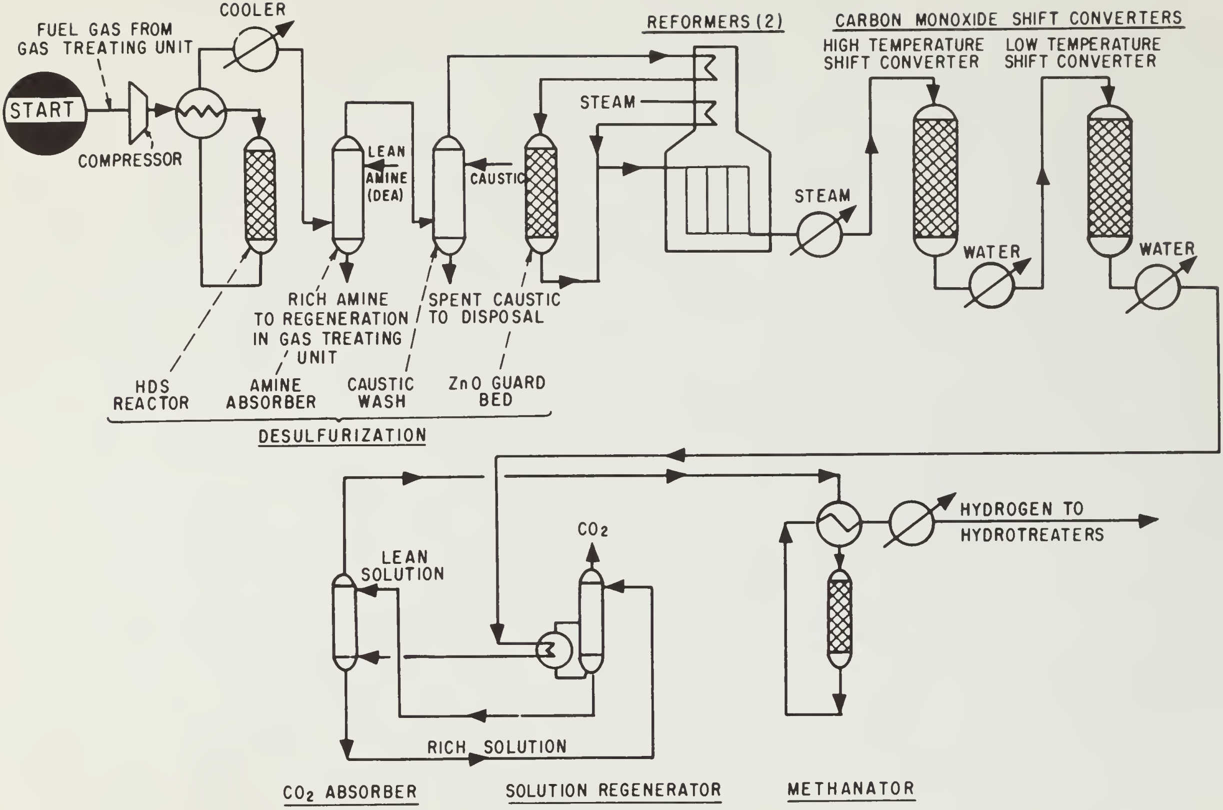


Figure IV—21 HYDROGEN UNIT, STEAM REFORMING PROCESS present. The rich solvent is then regenerated. Third, any residual traces of sulfur will be removed by chemical reaction with a zinc-oxide (ZnO) catalyst in a guard bed.

The desulfurized fuel gas will be mixed with superheated steam and reformed in tubes filled with a nickel-based catalyst at approximately 1400°F to 1600°F. The reformed gas will contain hydrogen, carbon monoxide, carbon dioxide and excess steam. This gas will be cooled and passed serially through two shift converters to react the carbon monoxide with steam to produce hydrogen and carbon dioxide. The first converter will be operated at high temperatures and will contain a mixture of iron and chromium-oxide shift catalyst. The second converter will be operated at lower temperatures and will contain a mixture of copper and zinc-oxide shift catalyst to achieve minimum residual CO content. The reforming furnaces will be fueled by treated gas.

The carbon dioxide-rich gas will be cooled and scrubbed with a lean solution to remove most of the carbon dioxide. The solution is circulated to a regenerator, where the CO_2 is released to the atmosphere. Any remaining carbon dioxide and carbon monoxide will be removed by heating the gas and passing it through a nickel-based methanation catalyst where the carbon oxides are reacted with hydrogen to form methane. The hydrogen product is sent to the naphtha and gas-oil hydrogenation units.

The hydrogen unit requires various catalysts which periodically need replacement. Spent catalysts will be either disposed of as described in Section V. I., Disposal of Other Wastes, or sent to offsite catalyst manufacturers for reclamation of metals.

4. Gas-oil Hydrogenation

The gas-oil hydrogenation unit treats a mixture of gas oil from the pyrolysis and delayed-coker units with hydrogen in the presence of a catalyst to produce a low-nitrogen, low-sulfur gas oil. The treated gas-oil product will be blended with treated naphtha product from the naphtha hydrogenation unit to form low-sulfur oil, which will be pipelined from the complex. This unit also produces diesel fuel which is used for mobile equipment in the mine and processed-shale disposal areas. A schematic flow diagram of this unit is shown in Figure IV-22.

Gas oil from the pyrolysis and delayed-coker units is blended with a mixture of recycled hydrogen and makeup hydrogen from the hydrogen unit. This feed is preheated to reaction temperature by effluent exchange and in a fired furnace. Arsenic is removed from the feed in reactors containing a proprietary catalyst. The gas oil and hydrogen mixture is then reacted at high temperature and pressure in the presence of hydrodenitrogenation (HDN) catalyst. This reaction substantially reduces the nitrogen content of the gas oil and removes almost all of the sulfur. Unsaturated hydrocarbons in the gas oil are also saturated in this process.

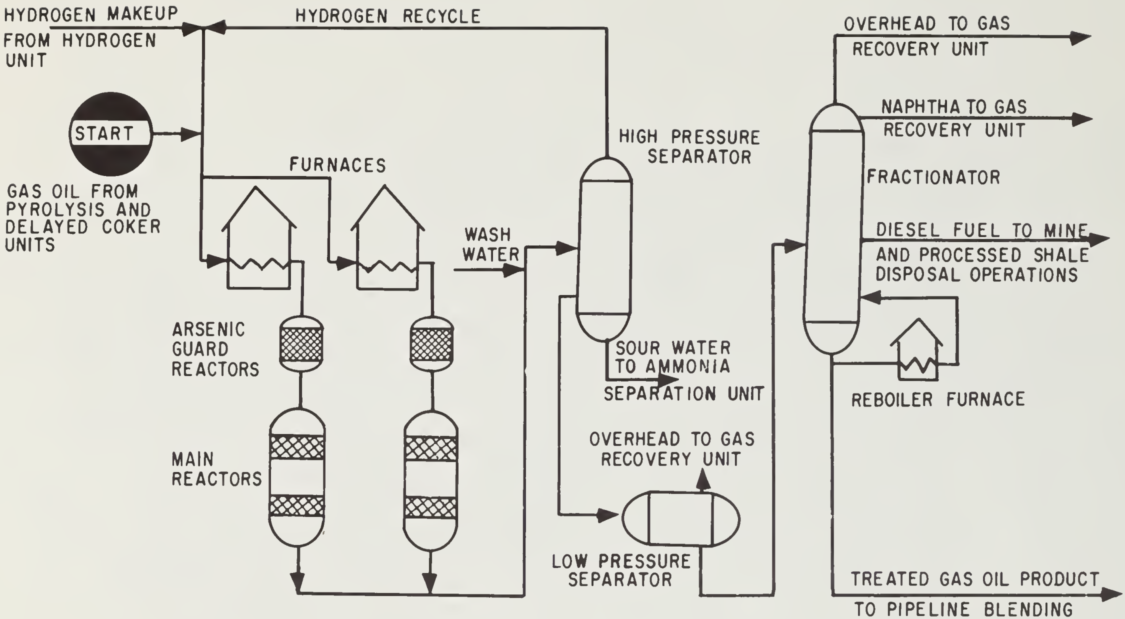


Figure IV—22 GAS OIL HYDROGENATION UNIT

Wash water is added to the reactor effluent to absorb hydrogen sulfide and ammonia. Sour water from the washing operation is sent to the ammonia separation unit for recovery of ammonia as a by-product. The hydrogen sulfide is separated from the ammonia and sent to the sulfur recovery unit. Stripped water from the ammonia separation unit is recycled to the naphtha and gas-oil hydrogenation units.

Overhead gases are flashed from the washed gas oil and the gas is sent to the gas recovery and treating unit. The washed gas oil is then fractionated to separate overhead gas, naphtha and diesel fuel from the treated gas-oil product. The overhead gas and naphtha are sent to the gas recovery and treating unit for gas treatment and naphtha stabilization. The diesel fuel is used in the mine and processed-shale disposal operations. The treated gas-oil product is blended with treated naphtha product to form the low-sulfur oil.

The two gas-oil hydrogenation feed furnaces and the fractionator reboiler furnace will be fired with treated fuel gas or fuel oil.

The hydrogenation reactor catalyst beds will require initial regeneration after one year to remove accumulated carbon deposits. During regeneration, carbon and other contaminants are burned off the catalyst in the presence of air and a diluent gas. Contaminants in the flue gas produced during catalyst regeneration will be controlled by conventional means to required emission levels before being exhausted to the atmosphere.

5. Naphtha Hydrogenation

The naphtha hydrogenation unit treats a stabilized naphtha blend from the gas recovery and treating unit with hydrogen in the presence of a catalyst to produce a low-sulfur, low-nitrogen naphtha. The treated naphtha product will be blended with treated gas-oil product from the gas-oil hydrogenation unit to form low-sulfur oil, which will be pipelined from the complex. This unit is quite similar to the gas-oil hydrogenation unit; however, the lighter naphtha requires less severe hydrogenation conditions than needed for the gas oil. A schematic flow diagram of this unit is shown in Figure IV-23.

Raw naphtha from the pyrolysis, delayed-coker and gas-oil hydrogenation units will be initially stabilized in the gas recovery and treating unit. This blend of stabilized naphthas will then be fed to the naphtha hydrogenation unit. The naphtha is first blended with a mixture of recycled hydrogen and newly produced hydrogen from the hydrogen unit and preheated to reaction temperatures in a furnace. This furnace will be fueled with treated fuel gas or fuel oil. The mixture is then reacted at elevated temperatures and pressures in the presence of hydrodenitrogenation (HDN) catalyst. While the reaction temperatures and pressures are not as severe as in the gas-oil hydrogenation unit, essentially all nitrogen and sulfur are removed from the naphtha and all olefins are saturated.

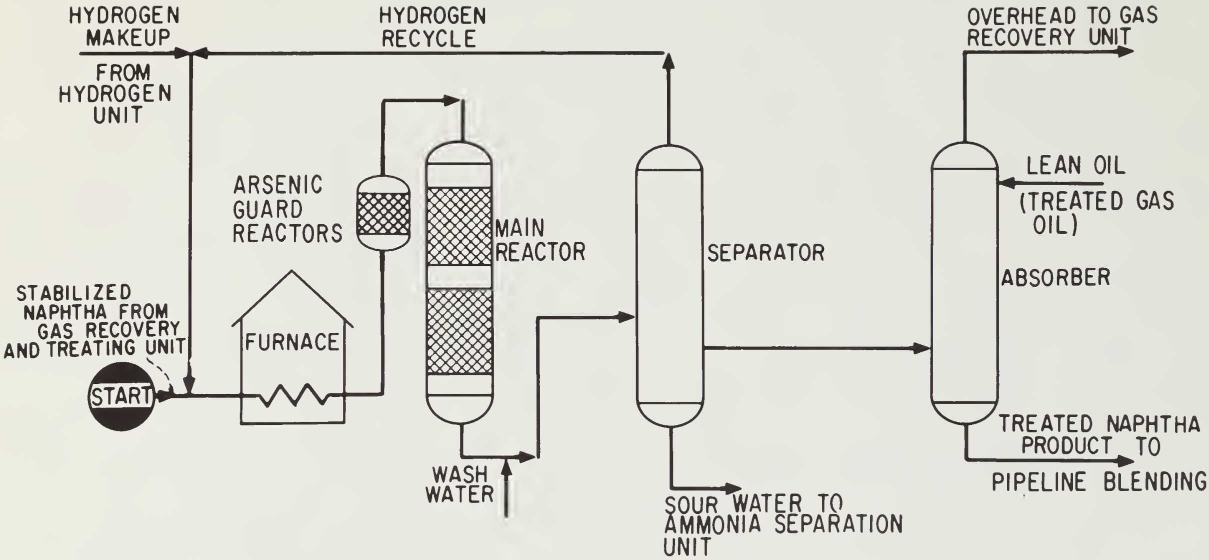


Figure IV–23 NAPHTHA HYDROGENATION UNIT

Wash water is added to the reactor effluent to absorb hydrogen sulfide and ammonia. Sour water from the washing operation is sent to the ammonia separation unit for recovery of ammonia as a by-product, while the hydrogen sulfide is separated from the ammonia and sent to the sulfur recovery unit. Stripped water from the ammonia separation unit is recycled to the naphtha and gas-oil hydrogenation units.

The washed naphtha and overhead gases are passed through an absorber where a lean oil (treated gas-oil product) absorbs the heavier hydrocarbons from the overhead gases. The overhead gas is then sent to the gas recovery and treating unit for acid-gas removal, and the treated naphtha product from the absorber is blended with treated gas-oil product to form the low-sulfur oil.

The hydrogenation reactor catalyst beds will require initial regeneration after one year to remove accumulated carbon deposits. During regeneration, carbon and other contaminants are burned off the catalyst in the presence of air and a diluent gas. Contaminants in the flue gas generated during catalyst regeneration will be scrubbed out by conventional means before being exhausted to the atmosphere.

6. Ammonia Separation

The ammonia separation unit processes sour water from the naphtha and gas oil hydrotreaters. Liquid anhydrous ammonia is produced as a marketable by-product. Gaseous hydrogen sulfide is removed and sent to the sulfur recovery unit and the stripped water is recycled to the hydrotreaters. A schematic flow diagram of the ammonia separation unit is shown in Figure IV-24.

The sour water from the hydrotreaters will be degassed to remove light hydrocarbons, which will then be sent to the gas recovery and treating unit. The hydrogen sulfide is then removed from the sour water in the H_2S stripper and sent to the sulfur recovery unit for conversion to by-product sulfur. The ammonia containing some residual H_2S is then removed from the sour water in the ammonia stripper and is purified to remove more H_2S, compressed, and cooled to form liquid ammonia. The liquid ammonia is sent to a storage vessel designed to hold the chilled, liquid ammonia under pressure without vapor leaks. Stripped water from the bottom of the ammonia stripper is recycled to the hydrotreaters. A small purge stream of stripped water is sent to the pyrolysis unit for moisturizing processed shale. A small amount of water is produced in the hydrogenation reaction.

7. Sulfur Recovery

Sulfur recovery involves a combination of two units. A Claus unit converts hydrogen sulfide to sulfur, which is recovered, and a tail-gas unit oxidizes unconverted hydrogen sulfide and unrecovered sulfur compounds from the Claus unit to sulfur dioxide, which is then recycled to the Claus plant for further treatment. This tail-gas unit vents to

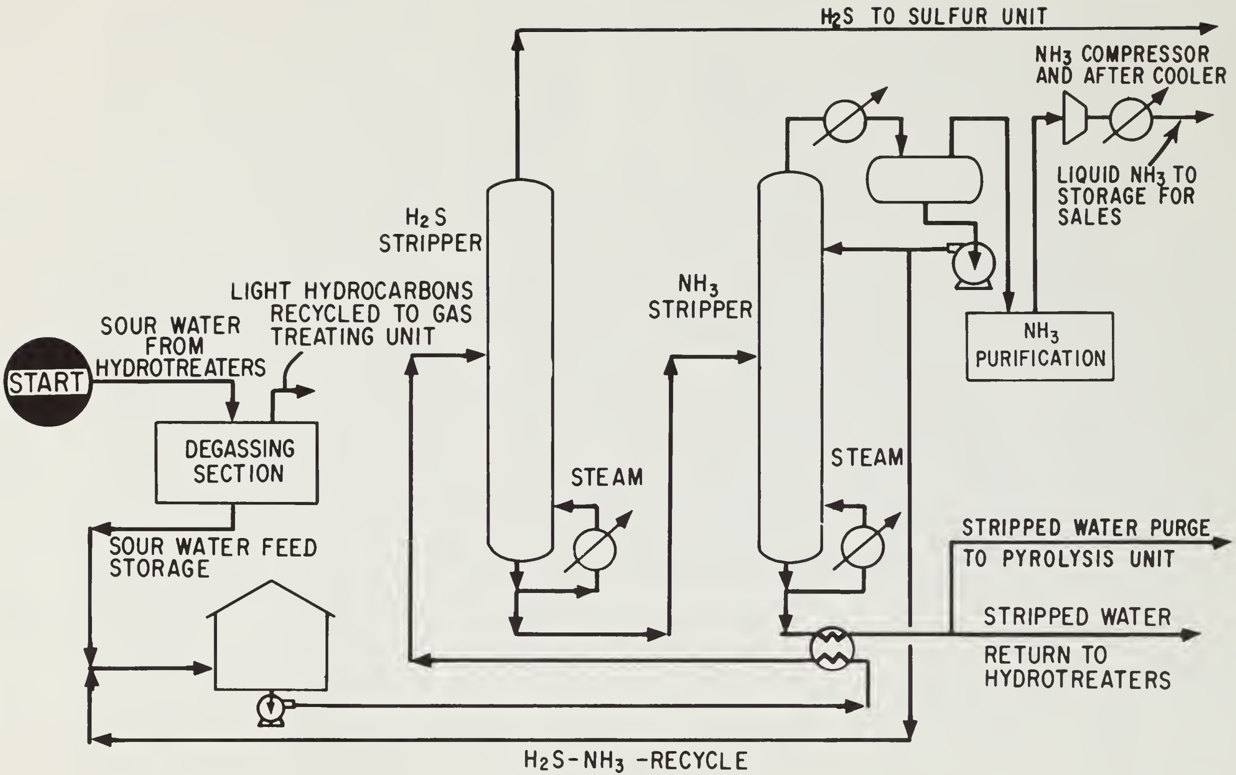


Figure IV–24 AMMONIA SEPARATION UNIT

the atmosphere. More specifically, the sulfur recovery unit removes and recovers sulfur from the hydrogen sulfide-rich acid-gas streams which emanate from the ammonia separation unit, the foul-water stripper and the gas recovery and treating unit. The function of this unit is to prevent the direct release of sulfur compounds to the atmosphere or the release of SO_2 by open flaring of acid gases. The unit converts these sulfur compounds into marketable liquid sulfur by-products.

The sulfur recovery unit consists of two Claus-type combustion trains which are operated in parallel. A single train is illustrated in Figure IV-25. Each train contains a reaction furnace and three catalytic conversion stages. Acid gas is converted to elemental sulfur in the reaction furnace and in the three catalytic conversion stages. The reaction involves partial combustion of the acid gas to form SO_2. The SO_2 reacts with the remaining H_2S to form elemental sulfur and water vapor. The hot reaction gases from the furnace are partially cooled in a steam generating section of the furnace. These gases are further cooled in an external condenser. The gases are then subject to stages of reheat, catalytic conversion and condensation. Sulfur is produced from each condenser. The Claus unit utilizes an activated bauxite (aluminum oxide) catalyst.

The bauxite catalyst used in the Claus units must be replaced about once every two years. The spent catalyst will be mixed with processed shale for disposal.

Exhaust gases from the Claus trains will be further treated in a tail-gas unit such as the Wellman-Lord SO_2 Recovery Process to reduce the remaining concentrations of sulfur compounds to about 250 PPM by volume sulfur, measured as SO_2. A schematic drawing of this process is given in Figure IV-26.

In the Wellman-Lord process the tail gas from the two Claus trains is incinerated at 1500°F, converting all sulfur compounds to SO_2. After passing through a waste-heat boiler, the hot gas is quenched with recirculating water. The cool gas is passed through an absorber where it is contacted with a recirculating sodium sulfite solution which removes SO_2. The clean gas is discharged to the atmosphere. The rich sulfite solution is regenerated in an evaporator-crystallizer. Sulfur dioxide and water vapor pass overhead from the evaporator to a condenser. A knockout drum separates condensed water for return to the absorbent dissolving tank and leaves a concentrated, saturated SO_2 stream to be piped back to the Claus plant feed. The solvent slurry is then redissolved and reused as lean solvent in the absorber. Waste streams from the process include acidic quench water, which is neutralized with caustic and overflows to the oily-water sewer. A small stream of sulfite solution is continuously purged to the pyrolysis scrubber makeup tank for eventual disposal with the moisturized processed shale.

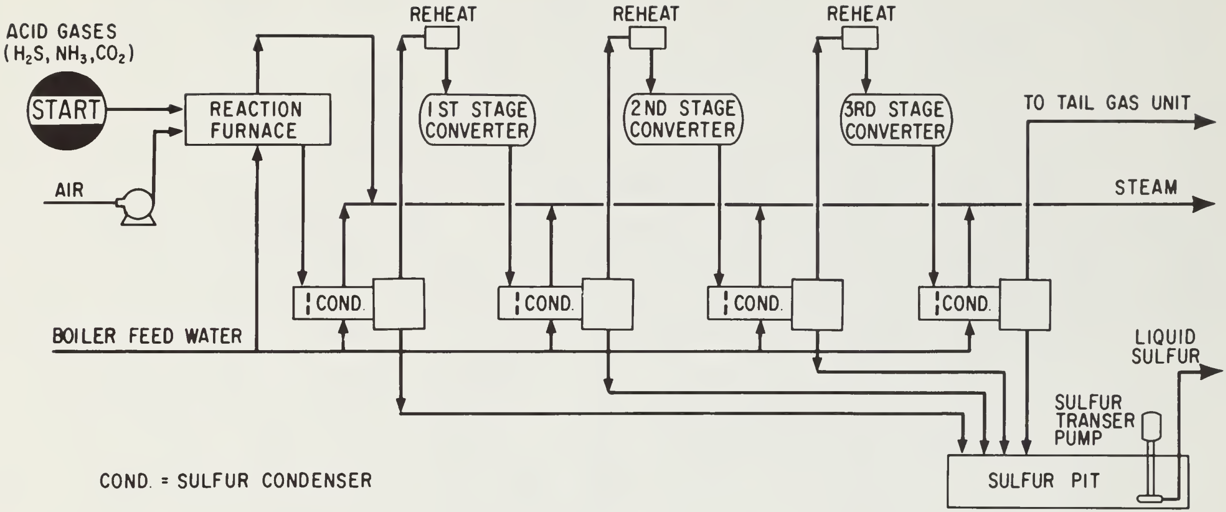


Figure IV–25 CLAUS SULFUR RECOVERY UNIT

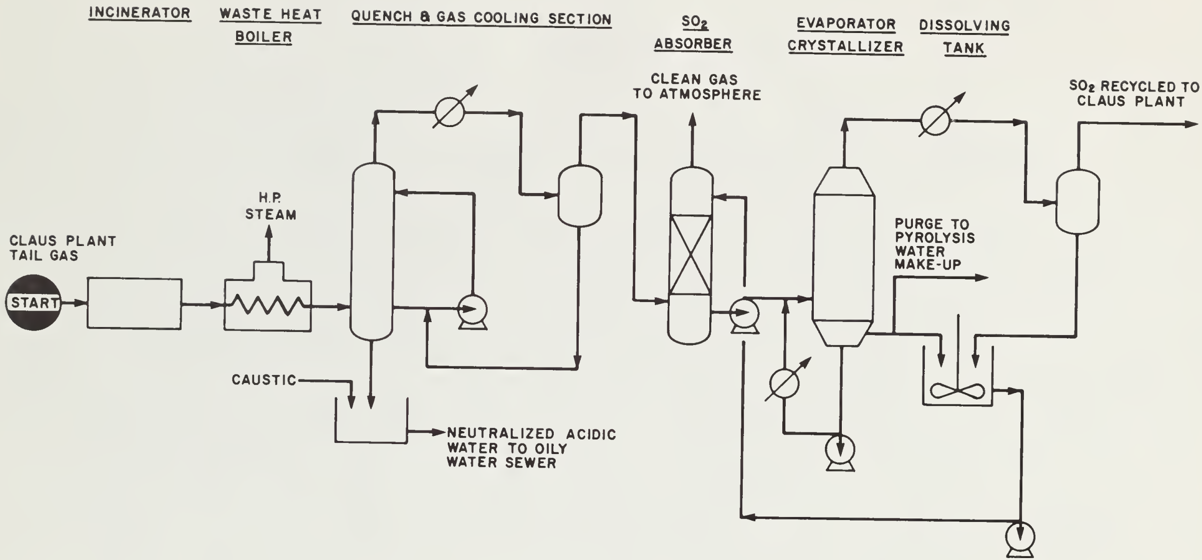


Figure IV–26 WELLMAN-LORD SULFUR TAIL GAS UNIT

8. Delayed Coking

The delayed-coker unit is an upgrading unit which converts the heaviest oil, known as bottoms oil, from the pyrolysis and oil recovery unit into lighter hydrocarbon products and by-product coke by thermal decomposition. The lighter products are fractionated into gas, naphtha and gas oil. Foul water is also produced from this unit. This water is removed in the fractionator. The major product of this unit is gas oil which is sent to the gas-oil hydrogenation unit for further upgrading. Approximately 35 percent of the bottoms oil is converted to coke. A schematic flow diagram of the delayed coking process is shown in Figure IV-27.

Bottoms oil is charged to the lower portion of the coker fractionator. The bottoms oil is then mixed with hot vapors from the coking drum. Light hydrocarbons are flashed from the heavy oil. The oil passes from the fractionator bottom to a furnace where it is heated to cracking temperatures and fed to one or two coke drums where coke is formed. The furnace is fired with treated fuel gas or fuel oil. Proper burner design will minimize nitrogen oxide emissions.

The vapors from the coking drum return to the fractionator. Here gas, naphtha, gas oil and foul water are separated and sent to various other upgrading units. The overhead gas and naphtha go to the gas recovery and treating unit for gas treatment and naphtha stabilization. The gas oil is sent to the gas-oil hydrogenation unit and the foul water is sent to the foul-water stripper. The heavier hydrocarbons are recycled to the coking operation.

When coke builds up to a pre-determined level in one of the coke drums, feed is diverted to the other drum so that the furnace operation is continuous. When coke has formed, it is stream stripped to remove light hydrocarbons, and then cooled by injecting water. High pressure water jets are used to cut the coke from the drums.

The water used for quenching and cutting the coke is collected in a separator pit. Coke fines in the water are removed by settling. The water is recycled for further quenching and coke cutting.

Coke is cut from the drums and falls onto a concrete slab. Cutting water discharges from the drum with the coke. The slab provides a place for the water to drain off the coke. After the coke has drained, but before it is entirely dry, the coke is loaded into trucks by a front-end loader and transported to storage prior to further shipment or use.

Although the coke contains low amounts of sulfur, it may have a high to moderate ash content due to the carryover of shale fines from the pyrolysis unit. The coke can be used as a power plant fuel; however, transportation costs and the quality and quantity of ash in the coke may

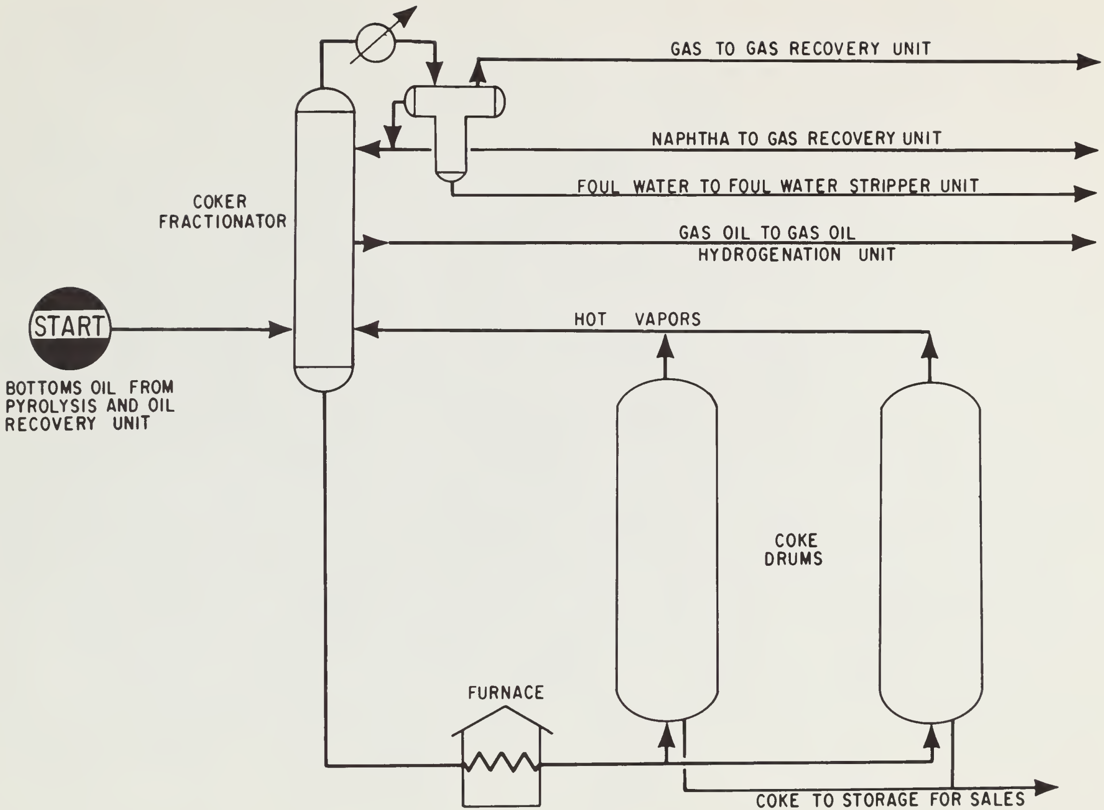


Figure IV–27 DELAYED COKING PROCESS

hinder sale of this product. The plans for utilization of the coke are to initially sell the coke as a power plant fuel if possible, or to upgrade it to metallurgical grade coke.

9. Foul-water stripping

The foul-water stripping unit removes H_2S and minor amounts of ammonia (NH_3) from foul-water streams which leave the pyrolysis and oil recovery unit, the gas recovery and treating unit, and the delayed-coker unit. The H_2S and NH_3 are sent to the sulfur recovery unit, where H_2S is converted to elemental sulfur and ammonia is converted to nitrogen. The stripped water is returned to the pyrolysis unit for moisturizing processed shale. The foul-water stripper is a conventional-distillation column with a steam-heated reboiler. A schematic flow diagram of this unit is shown in Figure IV-28.

10. Tankage

Tankage at the plant site is required for surge and temporary storage. Surge capacity is required between processing units to allow continuous operation of one part of the plant should another part be shut down for short periods. Tank storage of fuels used in mining, plant operations and processed-shale disposal is necessary to ensure an adequate fuel supply at all times. Storage of low-sulfur oil is provided prior to the product pipelining. A limited amount of tankage for LPG, ammonia and sulfur by-products is provided at the plant site. Table IV-5 describes product and intermediate tankage.

Governmental regulations and industrial design codes will govern the design of tankage and associated equipment. Vapor losses will be controlled by use of conservation vents and floating-roof tanks or vapor recovery systems as required by federal and state regulations. Tanks will be painted as necessary to control excessive temperature rises caused by solar radiation. The potential for liquid leaks will be minimized by designing all tanks and pumps in accordance with appropriate industrial design codes. Level alarm systems and automatic shutdown devices will be provided to prevent overflow accidents. These measures will help prevent fires from starting in the tankage area. If a fire occurs in the tankage area, fire fighting personnel will be utilized to contain and put out the fire. For more detail, see Section V. F., Health and Safety, and Section V. L., Oil and Hazardous Materials Spill Contingency plan.

The original wording of the environmental stipulations in the C-b Lease called for a spill containment volume in the tank dikes of 150% of the tank volumes. This volume, however, is excessive and substitutes a definite detriment to the environment (large additional area to be disturbed for the containment structures) in return for a questionable benefit (containment volume far in excess of that needed for any plausible accident). The tank farm will be designed in accordance with all national standards and regulations, including OSHA 1910.106 (b)(2), NFPA 30, Chapter II, and OIA #631. The dam in Sorghum Gulch would, of course, prevent any spillage from reaching the waterways even in the case of simultaneous catastrophic failure of all tanks and dikes.

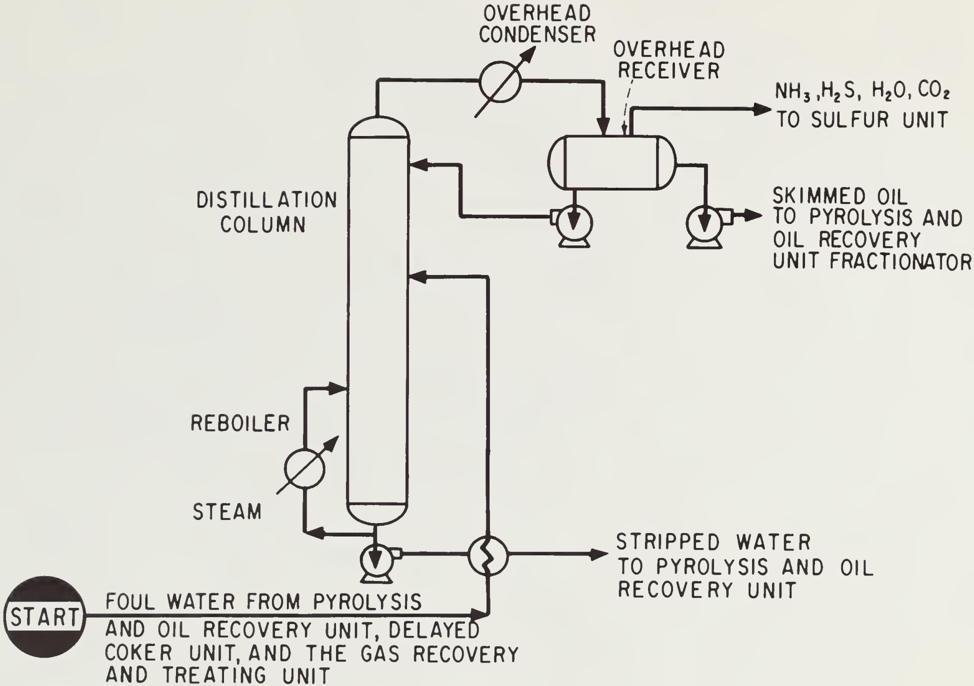


Figure IV–28 FOUL WATER STRIPPER

Table IV–5 PRODUCT AND INTERMEDIATE TANKAGE

Tank Service	Storage Capacity *BBL	Tank Description
Plant Site		
Coker Feed	110,000	Cone roof, two tanks @ 55,000 BBL ea.
Gas Oil Hydrotreater Feed	480,000	Cone roof, two tank @ 240,000 BBL ea.
Naphtha Hydrotreater Feed	260,000	Floating roof
Foul Water Stripper Feed	100,000	Cone roof
Gas Oil Hydrotreater Product	155,000	Cone roof
Naphtha Hydrotreater Product	110,000	Floating roof
No. 2 Diesel Fuel	4,000	Cone roof, two tanks 2,300 BBL at mine headframe 1,700 BBL at plant site
Plant Fuel Oil	100	Cone roof
"Butanes" Fuel	3,000	High pressure vessels
Oil-Water Separator Tank	2,000	Cone roof
LPG	4,000	Two high pressure vessels @ 2,000 BBL ea.
Ammonia	2,800	Two NH_3 vessels @ 1,400 BBL ea.
Sulfur	1,500	Enclosed Pit
Off-Tract Terminal		
LPG	20,000	High pressure vessels eight @ 2,500 BBL ea.
Ammonia	6,600	High pressure vessels three @ 2,200 BBL ea.
Sulfur	20,000 (3,000 long tons)	Cone roof

* The capacities shown are for net contents and do not include allowances for heel or vapor space. These capacities are based on production of 50,000 BPD of shale oil. Higher or lower production rates would modify tank capacities accordingly.

F. Waste Disposal

See sections V. G., Overburden Management, V. H., Processed-shale Disposal and V. I., Dipsosal of Other Wastes, for further details on Lessee's environmental control plans regarding waste disposal.

G. Water Use

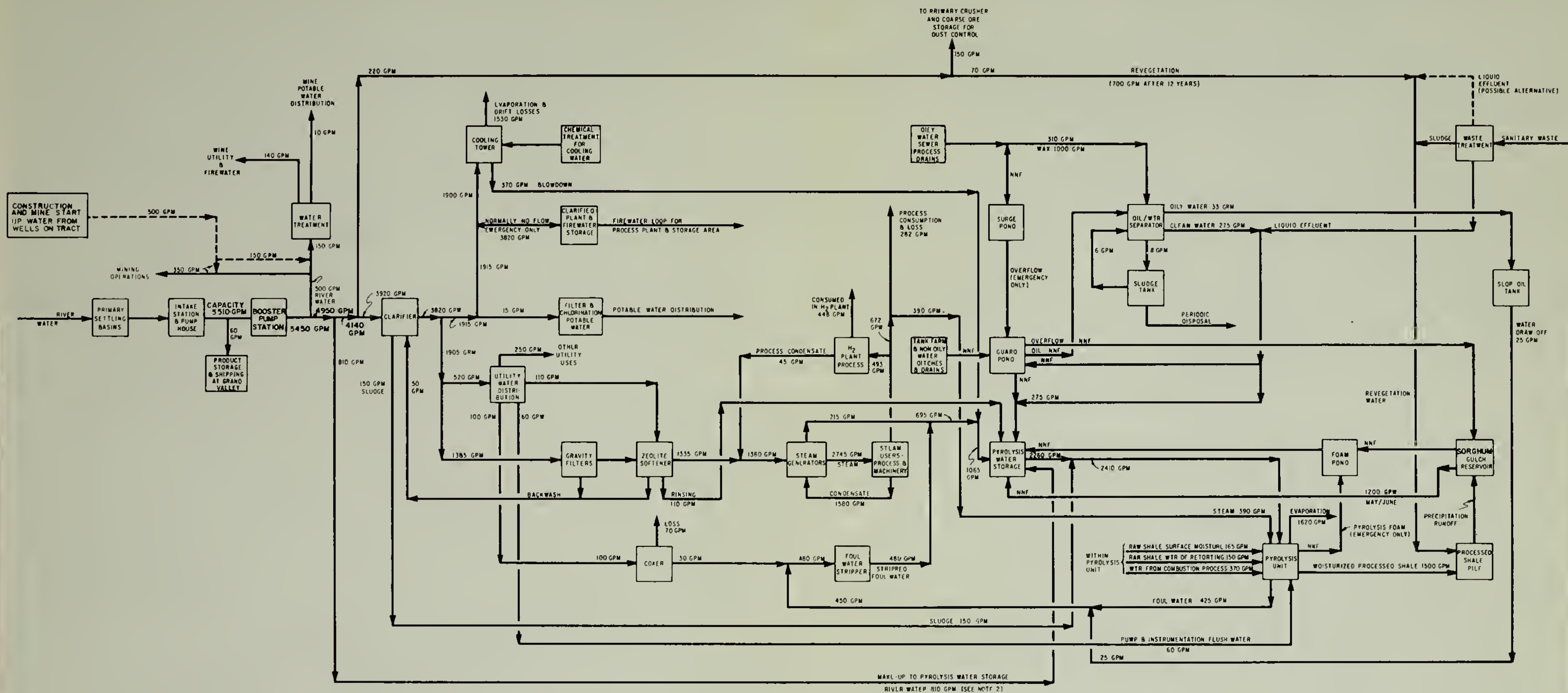
Water is utilized in a wide variety of operations within the mine and plant complex. The total consumptive use during normal operations will be approximately 5500 GPM (12.3 CFS) for a 50,000 barrel per day plant. The following tabulation and Figure IV-29 show plant water requirements by plant area, with approximate percentage distributions and form of use.

- mining (9%) - wetting down blasted shale and mine roads and suppression of drilling dust
- crushing, conveying and coarse-ore storage (3%) - suppression of dust with water sprays
- retorting and upgrading (55%) - cooling water, steam generation, hydrogen production, coke cutting and evaporation loss
- processed-shale disposal (28%) - dust control, moisturizing water and revegetation
- general plant and personnel use (5%) - utility water, fire protection, potable water and sanitary sewage

During construction, 800 to 1200 acre-feet of water per year will be required for concrete manufacture, dust control, compaction of grades and fill and other general and personnel uses.

All water supplied to the plant is eventually consumed or recycled in some way or released to the atmosphere by evaporation. There should be no water discharge beyond the Tract boundaries unless excessive mine water flows are encountered. A major consumptive use of water is the moisturization of processed shale, for which all waste water streams not otherwise recycled will be used. Water used for moisturizing processed shale for reclamation or for dust control on the processed-shale embankment will either evaporate, be permanently incorporated into the waste pile or will drain into the catchment basin for recycle. Other consumptive uses include steam generation in the reforming process to produce hydrogen for the hydrotreating units, use as drinking water, evaporation losses from the cooling tower, and use as irrigation water used in revegetation.

The plant cooling-water system is comprised of a complex network of piping over the entire processing area. About 36,000 GPM of cooling water will circulate within the plant and will eventually return to a multiple-cell cooling tower with an induced-draft air flow. Blowdown from the cooling-water system will go to the processed-shale moisturizer.



NOTES:

1 NNF - NORMALLY NO FLOW

2 RIVER WATER MAKE-UP TO PYROLYSIS WILL DECREASE WHEN OTHER WATER SOURCES SUCH AS PRECIPITATION RUN-OFF ARE AVAILABLE

Figure IV–29 WATER SYSTEM FLOW DIAGRAM

H. Electric Power Use

The required electric load for the complex, including the mining, crushing and processing units and excluding water pumping requirements, will be about 160,000 KVA connected load, with an operating load of 120,000 KVA. Electric load requirements and their approximate scheduling are shown in Table IV-6.

During early activity and while sinking the mine shafts, power will be generated on-site with portable generator sets totaling about 10,000 HP. A power supply will be brought to the Tract as soon as possible, as described in Section II. F. 1.

I. Utility Systems

1. Fuel System

The plant complex will be self-sufficient in gas and liquid fuels after it is on stream. During the initial plant start-up, purchased fuel oil will be burned. Three distinct fuels will be utilized in the complex: a treated fuel gas, a treated liquid mixture of butanes and butenes and a distillate fuel oil. All of the fuel gas and butane-butene liquid mixture produced in the plant complex will be consumed. The fuel oil will probably be gas oil, although the plant will be designed with the capability to burn naphtha or a blend of gas oil and naphtha. The heating values of the fuels are 20,300 Btu/lb. for fuel gas, 18,500 to 20,500 Btu/lb. for fuel oil, and 19,500 Btu/lb. for the butane-butene mixture. Fuel gas will be used as feed gas in the production of hydrogen.

Diesel fuel produced in the gas-oil hydrogenation unit will be used in the mine and processed-shale disposal operation. Approximately 400 to 500 barrels of diesel fuel per day will be used for diesel-powered equipment in these two areas. If raw shale oil instead of hydrotreated shale oil is selected as product, significantly larger quantities of pyrolysis-unit offgas would be available for use as plant fuels. Preliminary fuel balances for a plant designed to produce raw shale oil may have sufficient pyrolysis offgas to meet all fuel requirements during normal operations.

2. Steam System

Most of the plant requirements for steam will be met through the use of process-waste-heat boilers. High-pressure superheated steam will be produced in the two hydrogen-unit reforming furnaces and in steam superheaters contained in each pyrolysis train. Additional steam requirements will be met by two utility boilers. Steam levels of 900 pounds per square inch gauge pressure (PSIG), 400 PSIG, 150 PSIG, and 60 PSIG will be used.

Table IV–6 POWER REQUIREMENTS DURING VARIOUS PHASES OF DEVELOPMENT

USE	CONNECTED LOAD (KVA)
PHASE I	
Mine Shaft Sinking	4,000
Development Mining	5,000
PHASE II	
Commercial Mine Development	5,000*
Construction Water Pumping	3,000
PHASE III	
Water Pumping (Main & Booster)	10,000
Commercial Mine	60,000
Plant Operations	100,000
Total On-Tract Connected Load	160,000

*Gradually increasing to commercial requirements during Phase II

Where economically feasible, high-pressure steam will pass through turbines to drive rotating machinery before use in process heating. Medium and low pressure steam will be used for process heating and for winterizing plant equipment and systems. Steam condensate recovered from heating and other closed systems will be recycled to the steam generation units discussed above. Boiler blowdown will be sent to the processed-shale moisturizer. Foul and sour water recovered from process uses of steam will be processed in the foul-water stripper or the ammonia separation unit and either recycled or used to moisturize processed shale.

3. Compressed-air and Inert-gas Systems

A plant compressed-air system will be required to supply compressed air for general utility purposes and for operation of process control instruments. Compressors using combinations of electrical and steam turbine drivers will generate 125 PSIG compressed air, which will be dried to a $-40^{\circ}F$ dewpoint using parallel chemical drying beds.

A liquid-nitrogen system will be used to purge process vessels and lines during start-ups and shutdowns to prevent explosions, and may be used in certain tanks to prevent hydrocarbon emissions and gum formation in unstable hydrocarbon liquids. The nitrogen will be supplied from storage and will be distributed throughout the plant with a separate pipe network.

4. Flare and Blowdown System

The flare and blowdown system is a network of pipes that allows venting of process vessels and lines during start-ups, shutdowns and emergencies. Vented gas and liquid are first separated in a knock-out pot at the bottom of the flare system. Any collected liquid in the knock-out pot is sent to the oily-water waste system for processing while the gases are flared. The flare will be located a suitable distance from the processing area to reduce the effects of noise and emission concentration.

5. Communications System

Although the final plant communication system has not been designed, it is anticipated that a buried telecommunication duct will be installed within the utility corridor. An alternate microwave communication system may be installed.

J. Pipelines

1. Operations

Dispatching will be performed at a central location. Communications facilities will consist of a private microwave system and commercial telephone circuits, with a full duplex circuit to handle the supervisory system.

The supervisory system would consist of a master station at the central location and remote stations located at the Tract pump station and at the Lisbon Valley, Utah terminal. Each remote station can be interrogated by the central station, and all appropriate alarms, equipment status and throughput data will be visually displayed and/or logged at the central station.

The central station will monitor operating conditions at the Tract and Lisbon terminal and, with instructions initiated by the dispatcher, will be able to shut down or start up the system in the event of a malfunction, suspected leak or scheduling problem. Start-up and shutdown could also be accomplished at the Tract station. All remote-controlled gate valves could be activiated from either the dispatch center or from the Tract station.

2. Maintenance

A scheduled maintenance and pipeline inspection program will be followed upon startup of the pipeline system. Pipeline maintenance will emphasize the prevention of damage and deterioration of system components. Maintenance procedures will comply with the Department of Transportation Title 49, Part 195, Subpart F, "Operation and Maintenance Regulations."

The pipeline route will be marked by aerial route markers and ground markers to assist in patrolling the pipeline and to provide reference points by which maintenance crews could be directed. The aerial route markers will be spaced at regular intervals of approximately one mile. Ground markers will be placed at all highway, railroad and river crossings, and at other areas where necessary.

3. Oil Spill Contingency Plan

Section V. L., Oil and Hazardous Materials Spill Contingency Plan, delineates response actions to be employed in the event of a pipeline leak. The plan includes leak detection, automatic monitoring and control, and periodic manual monitoring.

Leak Detection. The detection of leaks is considered to be part of the standard operating procedures for pipeline personnel, and therefore continuous-monitoring equipment will be provided at the central control station. In addition to the equipment supplied for instrumental leak detection, visual inspection will be conducted on a scheduled and routine basis.

Automatic Monitoring and Control. Continuous monitoring for the detection of leaks and to insure continuity of the communication system will be done at the control center. Line parameters will be displayed at regular intervals and also can be demanded manually.

Large leaks will be indicated within a few seconds by pressure or flow deviation and small leaks by a volume balance of oil entering and leaving the system each hour. The following alarms will be located at the central control center.

- Pressure Deviation Alarm. In the event that a measured pressure at a station site deviates from a pre-set variation from normal or predicted operating pressures, the alarm will be activated. This alarm will indicate large leaks near stations or station sites. The pipeline system will automatically shut down should the pressure reach a pre-determined point.

- Flow Deviation Alarm. In the event that the flow measured at a station deviates from a pre-set valve by more than a small percent of rated output, this alarm will be activated.

- Flow Balance Deviation Alarm. In the event that the difference in flow rate from any station, as compared to the flow into the next station, deviates from a computer-stored value by more than a fraction of a percent of rated line throughput, this alarm will be activated.

  A computer calculation of total line volume balance is made each hour by comparing the volume of oil entering the pipeline system against the volume of oil delivered from the system. Whenever there is a cumulative imbalance of more than a pre-set value, an alarm would be sounded. Major or cumulative deviations will be considered cause to shut down the system.

Periodic Manual Monitoring. Visual aerial inspections of the pipeline route will be made about once per week. Aircraft will be tied into the communication system to ensure prompt reporting and action for normal operation and maintenance.

In the event that inclement weather prohibits aerial inspection for periods longer than one week, surface patrols will be made to ascertain dangerous conditions that might be developing along the pipeline. An inspection and service road will be maintained along most of the pipeline route. Patrols will be provided with radio equipment for both reporting and safety reasons.

The contingency plan was developed with due consideration to the environmental conditions encountered along the pipeline route. Formal training sessions in the procedures and techniques to be employed in the event of an oil spill will be conducted for all personnel assigned to the operation of the pipeline system.

K. Phase IV - Post-operations

Because the shale oil complex is expected to have a minimum operating life of about 20 years, it is difficult to predict at this time the disposition of the facility after the recoverable oil shale reserves beneath the Tract have been depleted. The disposition of the complex at that time will depend upon a variety of factors including:

- the future profitability of shale oil and associated mineral production
- potential changes or modifications to current retorting technology
- the feasibility of using the retorting and upgrading facilities to process shale from the Tract's lower zones, below the Mahogany zone
- the value of the complex to other reserve holders
- the extent of governmental participation in the oil shale industry at that time

Alternate methods of disposal may include a sale of the facility, dismantling the plant, or refurbishing the plant to process shale extracted from other reserves. Because of the range of possibilities, it would be misleading to state that any particular alternative is viewed as more probable than the others at this time.

If the plant complex is sold and the buyer assumes the Lease obligations, the Lessee would seek to obligate the buyer to assume responsibility for maintaining the processed-shale embankment and catchment dams. If the plant is modernized, the Lessee would continue to maintain the Tract in accordance with the Lease requirements. Assuming that the plant is neither sold nor modernized, the Lessee has developed plans for dismantling the facility. These plans, in general, will apply equally to any early or planned termination or completion of the project, insofar as activity to the date of termination requires specific decommissioning procedures. Specific plans for decommissioning each component of the plant are summarized below.

1. Retorting and Upgrading Facilities

After the operation of the plant is terminated, a multi-phase rehabilitation program will be implemented. The first phase will be to remove salable items. All vessels, pumps, compressors, aboveground pipe, structural steel facilities, steel tanks, buildings, and other salable items will also be disassembled and removed from the site.

Non-salvageable items remaining after the first phase will be knocked down and broken up during the second phase. Block or concrete buildings and concrete structures will be broken up and leveled close to grade. High concrete structures and foundations will be topped off. All hard-surface paving such as asphalt or concrete will be broken up in place. Underground pipes and culverts will be plugged, and left in place. Catch basins and manholes will be filled with earth and left in place.

The third phase will consist of earth-moving operations. Earth will be removed from the fill area at the process plant site. All foundations, knocked-down concrete rubble, and broken-up paved areas will be covered with earth to create a proper root zone for vegetation and to prevent subsequent weathering from uncovering rubble piles. After being broken up, paving will be covered over with at least one foot of earth. Treatment ponds and ditches will be filled. The earthen dikes surrounding the tanks in the tank farm will be leveled. Benches, sidehill cuts and fills will be smoothed out or filled in to create a rounded effect. The facing of reinforced-earth retaining walls will be removed. Concrete retaining walls will be demolished. Knolls will be rounded and sidehill slopes will be graded to appear much like the adjacent natural terrain. The gullies will be recreated as earth is relocated.

The last phase will be revegetation. During the earthwork phase, the ground will be slightly furrowed or ponded to capture natural precipitation. The regraded surfaces will be covered with topsoil, clean-water treatment sludge or non-oily-waste stockpiled during plant operation.

2. Crushing and Conveying Facilities

All mechanical items will be removed from the Tract. These items include stacker equipment, conveyor-drive equipment and crushers. The steel bents will be dismantled, cut up and removed. Buildings will be demolished and leveled to existing grade level. Concrete structures and storage silos will be demolished and leveled. Earth moving will be performed to return the graded areas as close to their original contours as practicable. The conveyor belt foundations will be covered with earth. Roads will be broken up and covered with earth, the side ditches will be filled, and the landscape will be rounded. The coarse-ore reclaim tunnel will be filled in and covered and the stacker tracks covered. The rubble piles created by knocking down buildings and silos will be dispersed, covered with several feet of earth and the fill rounded to conform with the terrain. This fill will probably come from the original plant-site fill area. Areas receiving fill will be covered with topsoil or sludge and revegetated.

3. Mine Surface Facilities

The rehabilitation of the mine surface facilities will be done in the same manner as the retorting and upgrading facilities previously discussed. All items that are marketable will be removed and sold. All building, structures, and other equipment in the vicinity of the mine shafts will be dismantled and removed from the site and the foundations taken down to grade. The crushing equipment may be removed from the mine. Hoisting equipment and head frames will be dismantled and removed from the Tract. The mine shafts will be backfilled with processed shale. The areas will be graded and revegetated to conform with surrounding terrain.

4. Off-tract Facilities

Buildings, tanks, high pressure storage vessels, utilities, pipeways, loading racks, railroad spurs and other off-tract facilities will be dismantled and everything above grade will be removed from the site. Foundations will be knocked down. Asphalt roads and railroad road beds will be obliterated, regraded and revegetated.

Underground piping inside the facilities will be plugged and left in place. The underground pipelines from the plant will be plugged at each end and left in place. If necessary, some of the excess earth from the plant site or the dams will be hauled and used to cover the foundations. Topsoil will be spread over the facilities site and the area will be revegetated in harmony with the surrounding area.

5. Off-tract Water Diversion Facilities

All facilities will be removed, including the river water intake structure, low-head and high-head pumps, grit chamber, settling basins, buildings, fencing and access roads. After removal of all equipment and structures, the site will be restored as nearly as practicable to its previous condition. The underground lines will be plugged and left in place.

6. Roads

Roads of minor significance will be obliterated by the removal of any gravel surfacing, retaining structures, culverts, drainage structures, guard rails, signs and other structures, and then graded to restore natural drainage patterns and revegetated.

7. Dams

There is a substantial possibility that the Lessee may sell the dams to the government or to local conservation or industrial interests. If the dams are not sold, the Lessee will either leave the dams as permanent drainage control structures, in accordance with appropriate government approvals and permits, or the dam site will be reclaimed as discussed below.

Exposed metal work will be removed and salvaged. The earth and rock fill material used for construction of the dams will be excavated and placed and compacted at both the spillway and borrow area or removed to other disturbed areas. The embankment material will be excavated only to the original ground line so that a smooth transition from natural ground to the ground under and behind the dams is provided. Spillway areas will be replaced with rock and fill material removed from the dam. Even though this replaced material is to be compacted, it is anticipated that because of swelling, excess material will remain. This excess material will be graded to contours that will blend with adjacent undisturbed areas. Regraded areas will be sloped to the drainages. Roads used during the operation of the dams and those developed for removal of the dams will be obliterated by finish grading.

All graded areas and areas changed by construction activities will be restored as nearly as possible to their original condition. All vestiges of construction within the project area will be removed so that the project area can be restored to near its original condition. The regraded area will then be revegetated.

8. Processed-shale Embankment

Lessee will develop a revegetated, stable surface on the processed-shale embankment which will be as resistant to local forces of weathering and erosion as is the surrounding soil. Under these circumstances, it will not be necessary to develop a permanent maintenance plan for the embankment. If for any reason longer maintenance is required, permanent maintenance plans or alternate disposal methods will be implemented as appropriate. Details of processed-shale revegetation are discussed in Section V. K., Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas.

9. Revegetation

All disturbed surface areas will be revegetated in accordance with the general procedures described in Section V. K., Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas.

V. Control Plans

V. Control Plans

V. ENVIRONMENTAL CONTROL PLANS

In connection with the development and eventual decommissioning of the shale oil complex, a variety of activity will take place which has been described in the foregoing sections. Under the terms of the Lease and a multitude of other federal, state and local laws and regulations, those activities will be controlled to minimize environmental effects and to provide a healthy and safe working environment. The Lessee's plans and procedures for compliance with the Lease and with applicable law and regulations are set forth in this section. Included are the following specific plans:

A. Air Pollution Control
B. Water Pollution Control
C. Noise Pollution Control
D. Protection of Objects of Historic and Scientific Interest and Aesthetic Values
E. Fire Prevention and Control
F. Health and Safety
G. Overburden Management
H. Processed-shale Disposal
I. Disposal of Other Wastes
J. Fish and Wildlife Management Plan
K. Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas
L. Oil and Hazardous Materials Spill Contingency Plan
M. Off-tract Corridors

These plans address the controls to be used in connection with the activity in Phases I, II, III and IV as follows:

Phase I - Mine Development. Phase I will involve: engineering design and procurement; preparing a mine site and sinking two approximately 30-foot diameter vertical shafts; installing underground crushing equipment and surface conveyors; building mine surface facilities; constructing on-tract service roads and an all-weather access road between the Tract and the existing Piceance Creek road; preparing a coarse-ore stockpile area near the head of Cottonwood Gulch; constructing a water catchment dam in Sorghum Gulch; and constructing a runoff control dam below the coarse-ore stockpile in Cottonwood Gulch. Interim water and power facilities will be installed and a water disposal facility will be constructed. This initial work is scheduled to take approximately three years to complete. After the shafts have been completed, mine development work will begin and continue for approximately another two years.

Phase II - Plant Construction. After the development mine has been completed, construction of the commercial plant will begin in about 1981. Construction will take about four years. During this time the retorting and upgrading facilities will be constructed; the coarse-ore stockpile expanded; the surface and underground mine support facilities installed; the commercial primary and secondary crushing, handling and storage facilities completed; and the processed-shale handling facilities constructed. Also during this period, all associated off-site facilities, including the off-tract staging area terminal, water diversion facilities, and the water, shale oil and by-products pipelines will be completed.

Phase III - Plant Operation. Commercial operation of the shale oil complex after construction will proceed for approximately 20 years until such time as all economically recoverable oil shale beneath the Tract has been mined and processed.

Phase IV - Post-operations. Following commercial operation will be a period of post-operation activity, during which time steps will be taken to decommission the project in an environmentally acceptable manner. This phase will include closure of the mine and restoration of sites utilized for mining, raw shale storage, conveying, retorting and upgrading, roads, processed-shale disposal pile, dams, corridors, staging areas and miscellaneous other facilities.

The various plans are organized by subject and each plan stands separately, although there is obviously considerable interrelationship among the various plans. The plans contain a statement of the nature of activities which require control, a summary of the Lease terms as well as applicable law and regulation, and the substantive plan describing procedures to be used for controlling undesirable effects of development and operational activity.

Air Pollution Control

V. A. Air Pollution Control

1. Proposed Activity Affecting Climate and Air Quality

   a. Phase I - Mine Development
   b. Phase II - Plant Contruction
   c. Phase III - Plant Operations
   d. Phase IV - Post-operations

2. Lease Requirements, Applicable Law and Regulations and Control Plans

   a. Lease Requirements
   b. Applicable Federal Air Standards and Control Plans

      (1) Ambient Standards
      (2) Non-deterioration Regulations
      (3) New Stationary Source Performance Standards
      (4) National Emission Standards for Hazardous Pollutants

   c. Applicable Colorado Air Standards and Control Plans

      (1) Ambient Standards
      (2) Regulation No. 1
      (3) Regulation No. 2
      (4) Regulation No. 3
      (5) Regulation No. 6
      (6) Regulation No. 7
      (7) Regulation No. 8

   d. Diffusion Modeling Program and Predicted Ambient Concentrations

      (1) Diffusion Modeling Program
      (2) Retorting and Upgrading Facilities
      (3) Access Corridors

A. Air Pollution Control Plan

This plan has been prepared to evaluate development activities which may potentially affect climate and air quality, to review the applicable Lease provisions, law and regulations, and to set forth a compliance plan.

1. Proposed Activity Affecting Climate and Air Quality

Air quality will be affected by the addition of dust, hydrocarbons, carbon monoxide, sulfur dioxide and nitrogen oxides as a result of construction activities, day-to-day plant operations and the increased population anticipated as a result of the Lessee's plan of development. The plant will also generate quantities of steam and water vapor, and some odors characteristic of oil shale retorting operations.

The area primarily affected by these pollutants will be the Tract and the immediate area surrounding the Tract as a result of various construction and operational activities. Piceance Creek valley and the surrounding area may also be affected as a result of plant emissions, road construction and improvement, and daily traffic to and from the Tract during construction and operation. To a lesser extent, the multi-purpose corridor to the south of the Tract will be affected by the construction of shale oil, ammonia, LPG and water pipelines. Construction of communication systems and power lines will have a small effect on air quality. Staging areas, terminal facilities and railroad sidings located near Rifle will also be slightly affected by the Lessee's activities.

This section discusses the nature of activity which may affect climate or air quality in the various phases of activity and quantifies the potential pollutants which could be generated. In general, the major impact will occur in Phases II and III (Plant Construction and Plant Operations) as opposed to the relatively minor impacts of Phase I (Mine Development) or Phase IV (Post-operations).

a. Phase I - Mine Development

Fugitive dust will be generated during Phase I by earth-moving operations, soil stockpiling, construction of mine surface facilities, mine shafts, conveying and coarse-ore stockpiling, water retention dams, shaft muck disposal, and vehicular movement on unpaved roads. Some blasting is expected to be required in the construction of mine shafts, retention dams and roads. The temporary generation of fugitive dust and blast fumes is unavoidable.

Prior to the installation of permanent power lines, it is expected it will be necessary to generate electrical power on-site to sink the mine shaft. One or more diesel-powered generators with approximately 4000 to 6000 kw total capacity are planned at present.

Utilizing Environmental Protection Agency (EPA) Document AP-42, the estimated emissions for generator sets of 6000 kw capacity (equivalent to 4.91 x 10^8 Btu on a 24-hour basis) using distillate fuel oil are:

Pollutant	Emissions (lbs./day)
Particulates	29.5
SO_2 (0.1% Sulfur in fuel oil)	49.1
NO_2	413

Underground activities will include mining (drilling, blasting, loading, hauling, scaling and roof bolting) and primary-crushing operations which will produce fugitive dust and blast fumes. Blast fumes will include carbon monoxide and nitrogen oxides. All underground mobile equipment will be diesel powered, and will consequently produce carbon monoxide, nitrogen oxides and unburned or partially-oxidized hydrocarbons such as aldehydes.

The removal of coarse ore from the mine via the mine shafts and the conveying and stockpiling of this coarse ore will also be sources of fugitive dust. If the coarse ore is hauled on a temporary basis, diesel emissions will also be produced.

Transportation of construction workers, miners and other operating personnel on roads to and from the Tract will generate vehicular exhaust.

Due to the relatively small scale of development activities taking place during Phase I, little change in the existing quality of air in this portion of the Piceance Creek basin is expected. Air quality stations will continuously monitor for various contaminants in order to detect any air quality changes that take place.

The construction and development mining activities planned for Phase I are small in comparison to the major construction activities for Phase II and the commercial mining and oil shale processing activities planned for Phase III; and since only moderate to small releases of heat, emissions or water vapor will occur, no significant impact on the climate of the Piceance Creek basin is expected during Phase I.

b. Phase II - Plant Construction

During Phase II, dust will be generated during road construction, construction of oil, water, ammonia and LPG pipelines, construction of communication systems and power lines, movement of vehicles, earth-moving operations, blasting, dam construction, and construction of other surface facilities. While precise predictions of fugitive dust are not possible, fugitive dust emission factors from the EPA Document AP-42 are given below and can be used for preliminary estimates:

Source Category	Emission Factor
Unpaved Roads	3.7 lb/vehicle-mile
Construction	1.4 tons/acre/month of active construction

The operation of diesel equipment during the construction period will produce unburned hydrocarbons, aldehydes, organic acids, carbon monoxide, nitrogen oxides and smoke. Emission factors for heavy-duty, diesel-powered vehicles (EPA Document AP-42) are estimated to be 20.4, 3.4, 34.0 gm/mile for carbon monoxide, hydrocarbons and nitrogen oxides, respectively.

During construction, a maximum of 3000 to 3300 workers will be employed on a three-shift basis. Primary access to the Tract will be via the existing Piceance Creek road. It is estimated that approximately 500 cars and 20 trucks, traveling at an average speed of 35 mphs, represents a reasonable maximum in the eastern segment of Piceance Creek valley during the early morning shift change. If an altitude of 6500 feet and an average vehicle model year of 1973 are assumed, then EPA and State of Colorado automobile and truck emission factors can be used to estimate emission rates of 52,700 gm/hr of nitrogen oxides, 987,000 gm/hr of carbon monoxide, and 73,900 gm/hr of total hydrocarbons.

c. Phase III - Plant Operation

During Phase III, the construction and operation of the plant complex will produce the majority of the emissions expected during the life of the project. The base case used for developing the estimated emissions is the construction and operation of a six-train, TOSCO II retorting system with upgrading facilities capable of producing 45,000 bpd of hydrotreated shale oil. Also being considered is the production of raw or partially treated shale oil. In general, a reduced degree of upgrading would also reduce air contaminant emissions.

Actual emission parameters cannot be developed prior to a definitive engineering design. Projected methods of pollution control are subject to change, and the proposed plant will be designed, wherever feasible, to accommodate future advances in control technology.

A summary of the estimated range of emissions from various point sources within the retort and upgrading units is given in Table V-1. This table lists the estimated range of emissions of sulfur dioxide, nitrogen oxides, particulates, hydrocarbons and carbon monoxide from plant stacks. These emission estimates are listed according to the operating functions described in Section IV. E. Specific contaminants are discussed below.

Sulfur Dioxide. SO_2 will be emitted from combustion processes and from a tail-gas plant in the sulfur recovery unit. Hydrogen sulfide is

Table V–1 SUMMARY OF ESTIMATED EMISSIONS: HYDROTREATED SHALE OIL CASE

Estimated Normal Emissions, lb./hr.

Source (1)	Sulfur Dioxide	Nitrogen Oxides	Particulates	Total Hydro-Carbons	Carbon Monoxide
Crushing and Conveying:					
Final Crusher Dust Collection System	0	0	30-50	0	0
Fine Ore Storage Dust Collection System	0	0	5-10	0	0
Misc. Transfer Points	0	0	20-30	0	0
Pyrolysis and Oil Recovery Unit:					
Preheat Systems (6)	50-60	1400-1600	250-300*	250-300	40-50
Steam Superheater - Ball Circulation Systems (6)	80-120	110-130	200-250	< 1	< 5
Processed Shale Moisturizing Systems (6)	0	0	250-300	0	0
Hydrogen Unit:					
Reforming Furnaces	25-35	80-100	10-15	< 3	10-15
Gas Oil Hydrogenation Unit:					
Reactor Heaters	< 1	< 5	< 1	< 1	< 1
Reboiler Heater	< 5	10-15	< 3	< 1	< 1
Naphtha Hydrogenation Unit:					
Reactor Heater	< 1	< 3	< 1	< 1	< 1
Sulfur Recovery Unit:					
Sulfur Plants with Tail Gas Plant	90-110	Nil	Nil	Nil	Nil
Delayed Coker Unit:					
Heater	< 5	5-10	< 2	< 1	< 1
Utilities:					
Boiler(s)	10-15	20-30	< 5	< 5	< 5
Totals	267-352	1633-1893	777-967	263-313	64-79

Other Sources (2)					
Flare	X	X	X	X	X
Oil Storage				X	
Cooling Towers					
Catalyst Regeneration	X	X	X	X	X

(1) Where multiple sources are indicated, emission rates are for all sources.

(2) An X denotes the potential emission of a particular contaminant, but the release is usually temporary and accurate estimation of an emission rate is not possible.

(*) Includes condensible hydrocarbons

present in retort gases and in this form is a potential contaminant from process spills and leaks. However, most of the H_2S in the fuel gas, as well as sulfur contained in plant fuel oil, will be converted into sulfur dioxide by combustion in various process burners. Estimated SO_2 emissions from the plant range from 267 to 352 lb/hr., and are based on the sulfur content of the plant fuel gas and fuel oil and on observed emissions from the TOSCO 25 tpd pilot plant and the Colony 1000 tpd semi-works plant operations.

Nitrogen Oxides. Estimates for NO_x emissions range from 1633 to 1893 lb/hr for full plant operations.

Particulates. Solid particulates will be emitted from secondary crushing, the fine-ore storage silo, raw-shale preheating, processed-shale wetting and ball-circulation system operations. According to Colorado regulations, condensible hydrocarbons must be considered particulates. Estimates of the particulate emissions produced by fuel combustion are based on EPA omission factors (EPA Document AP-42) for gas, butane and distillate oil combustion. Estimated emissions from the plant range from 777 to 967 lb/hr. During occasional soot blowing, boiler "lancing," and fuel switching, additional smoke and dust may be released.

Hydrocarbons. Trace hydrocarbons at concentrations of approximately 90 ppm will be contained in flue gases from the retort preheat systems after incineration and scrubbing. These concentrations, together with other hydrocarbons emitted from other sources in the plant complex, range from 263 to 313 lb/hr. About half of these hydrocarbons emitted from the preheat system will be condensible at exhaust conditions and therefore are classed as particulates in accordance with Colorado regulations. Minor quantities of hydrocarbons are produced in any combustion operation. Estimates of hydrocarbon emissions produced by fuel combustion are based on EPA emission factors (EPA Document AP-42) for gas, butane and distillate oil combustion. The operation of diesel equipment during mining and processed-shale disposal operations will produce unburned hydrocarbons, aldehydes, organic acids and smoke (carbon particles). Intermediate and product-oil storage facilities may be a source of potential hydrocarbon losses. The retorting process is designed for complete recovery of hydrocarbons from raw shale; however, if under upset conditions retorting is incomplete due to insufficient temperatures or residence time, the resulting processed shale may emit hydrocarbon vapors. These conditions will occur infrequently.

Carbon Monoxide. Quantities of carbon monoxide are produced in any combustion reaction. Estimates of carbon monoxide emissions are based on EPA emission factors (EPA Document AP-42) for gas, butane and distillate oil combustion and range from 64 to 79 lb/hr. The diesel equipment used in the mine and processed-shale disposal operations will also produce carbon monoxide.

Other contaminants or constituents which will be released by mine and plant operations, but which cannot be quantified, are discussed below.

Fugitive Dust. Mining, hauling, dumping and conveying of raw oil shale will produce some fugitive dust. The dumping and reclaiming of coarse ore at the stockpile may also produce dust. The handling, conveying and disposal of processed shale will be a potential source of fugitive dust. Coke cutting, dumping and loading are other potential sources of fugitive dust.

Water Vapor. One-half to three-fourths of the water required for the plant is returned to the ecosystem by evaporation. Emission of water vapor is not considered a contaminant. However, water vapor emitted from cooling towers and wet scrubbers can create steam plumes under certain atmospheric conditions, and can affect the scenic quality of the area. The total water vapor released to the atmosphere may cause an increase in local humidity, may increase the potential for fog and cloud formation and may increase the occurrence and severity of icy conditions during the winter months. Dry air, high frequency of strong solar radiation, and the prevailing wind over the semiarid Piceance Creek basin should cause the released water vapor to be absorbed and dissipated in the regional air system.

Odor. During operation of experimental oil shale retorting facilities, a characteristic odor was readily detected throughout the processing area. This odor is very similar in character to the odor of mined rock and local talus formations, except that the odor is more concentrated. It is expected that some odor from the upgrading units will be noticed within the immediate area.

Ammonia. Since the complex will produce ammonia as a by-product from the hydrotreating of naphtha and gas oil, the potential exists for the release of ammonia to the atmosphere from spills and leaks.

Oil Spills. The potential exists for hydrocarbon emissions from spills or leaks of volatile hydrocarbon liquids (See Section V. L., Oil and Hazardous Materials Spill Contingency Plan.).

Additional contaminants or emissions will be produced during Phase III plant start-up, turnaround activities and flaring, and as a result of vehicular traffic.

Plant Start-up and Turnaround Activities. The initial plant start-up will be a temporary source of significant emissions since much of the pollution control equipment will also be operating in the plant for the first time. Start-up activities can be scheduled so that upgrading units such as gas treating and sulfur recovery units, will be in operation as soon as possible, thereby minimizing the flaring of untreated gases.

Subsequent plant start-ups after regularly scheduled turnarounds will also produce temporary emissions, but these will be shorter in duration due to previous equipment operation and experience gained during previous start-ups. Plant turnarounds will be regularly scheduled to perform routine equipment maintenance and to remove accumulated deposits in reactors and process vessels. Such maintenance operations as welding, sand blasting and use of water jets, along with catalyst regeneration or replacement, will generate temporary emissions of dust and fumes.

Flaring. One or two flares will be used to burn various combustible gas streams from the retorting and upgrading facilities during start-ups and upset conditions. Only a minimum of flaring is expected during normal operations. Flaring will prevent direct release of hydrocarbons or hydrogen sulfide to the atmosphere.

Traffic. During operations, a working force of 1000 to 1200 workers employed on a three-shift basis will travel to the Tract from the surrounding area. The amount of vehicular emissions during operations will be about one-third of those produced during the construction period.

Diffusion models are used for the prediction of ambient air contaminant concentrations resulting from operation of the plant and emissions from auto and truck traffic. Such models are used to demonstrate compliance with existing federal and state ambient air quality standards.

The prediction of ambient concentrations of pollutants involves complex mathematical calculations. Because of the complexity and large number of calculations involved, such calculations are usually performed on a computer. In predicting the ambient concentrations which result from plant emissions, the emission rates, stack heights, discharge temperatures and velocities need to be known, as well as some knowledge of the local topography and climate. At this stage in the C-b Project, a detailed knowledge of the above parameters or of the regional climatology has not been developed. An approach to this problem has been to develop ambient air quality predictions in various stages, each stage becoming more improved and refined as more information becomes available. The first stage in this plan, which is described in greater detail below, uses a simplified Gaussian plume model to predict the ambient concentrations from the plant complex and a box model to study the effect of auto and truck emissions on ambient concentrations in the Piceance Creek valley. Subsequent stages (subject to change as more data become available) will use state-of-the-art models of increased sophistication, and possibly tracer or wind-tunnel experiments.

Some small, local effects on the climate could occur during the major activities planned during Phase III, and these effects can be described as follows:

- Increased air temperatures in the immediate vicinity of the plant complex will be produced by the active portions of the processed-shale embankment and by hot stack gases. The impacts of the resulting convection currents upon local wind patterns and air turbulence above the plant should be insignificant. The topographical changes produced by the processed-shale embankment may affect local meteorological patterns to a small degree.

- Releases of water vapor could slightly increase local humidity and downwind precipitation. The regional effects are expected to be insignificant. Evaporation and the various water vapor releases do constitute a return of water to the ecosystem and can therefore be considered a positive impact. Under certain conditions, water vapor carried by cold air draining into the valleys could increase the formation of fog. The release of water vapor and other emissions may slightly reduce solar radiation as measured on the surface.

- The heat release from plant stacks and the processed-shale pile in Sorghum Gulch may slightly effect diurnal wind patterns. This heat could interfere with typical early evening drainage of air into Piceance Creek valley in the vicinity of Sorghum Gulch. The cumulative effect is expected to be insignificant.

- The rate and intermediate steps involved in the ambient chemical reactions which generate the combination of products commonly identified as "smog" are influenced by many complex factors. These include the relative concentrations of reactants, the degree of photoactivation, variable meteorological dispersive forces, and the influence of local topography, temperature, and relative amounts of moisture. Meteorological dispersion is, in turn, related to the degree of containment beneath inversions, the magnitude of horizontal and vertical wind movements, the degree of turbulence induced by convective and non-linear flow, and precipitation. The systems which produce smog are so complex and variable that reliable predictions of this type of air pollution are unattainable at the present time. More sophisticated technology will have to be developed before adequate prediction of this phenomenon can be made.

The above paragraphs have discussed types of emissions expected and use of diffusion models for prediction of associated ambient concentrations. A specific description of the diffusion modeling programs are contained in Section V.A.2.d. During Phase III, monitoring of stack emissions will be accomplished in compliance with the appropriate regulations and guidelines as discussed in Section VI.E. The operational air quality control plan will consider fuels management, practical use of tall stacks, pollution control equipment and careful monitoring for potential air-pollution episodes. Transportation plans and busing, car-pooling, shift-scheduling and transportation routing to control pollution will also be considered. Further detail on control plans follows in Section V.A.2.b.

d. Phase IV - Post-operations

Some fugitive dust and diesel exhaust emissions will be generated by equipment dismantling and earth contouring activities, although generally to a lesser degree than during Phase II. Vehicular exhausts from transportation of workers will also be produced, again to a much lower level than during Phases II and III.

While the dismantling and earth moving activities planned during Phase IV are directly opposite in purpose but similar in scope to the construction activities of Phase II, no large releases of heat, emissions or water vapor are likely, and so no noticable effect on the regional climate or ambient air quality will likely occur during Phase IV.

2. Lease Requirements, Applicable Law and Regulations and Control Plans

The following section discusses Lease provisions and federal and state law and regulations applicable to the project, and describes the actions which will be taken to comply with such requirements.

a. Lease Requirements

Section 11 of the Lease and Section 8 of the Stipulations require compliance with all applicable federal, state and local air pollution and air quality regulations, including emission regulations limiting the quantities of air contaminants which can be emitted from various sources, and ambient air quality standards which define maximum permissible ground level concentrations of various air contaminants. Ambient air quality standards, which have been promulgated to protect public health and welfare, are of particular importance since they define the maximum permissible level of impacts from the proposed operations. These standards are included in the following discussion for the sake of completeness.

Emission sources, rates, stack heights and discharge parameters have been estimated for the proposed facility. However, such data are subject to change in developing a definitive engineering design. The following discussion relates to Phase III and is intended to identify applicable regulations and to summarize procedures to be utilized to ensure compliance.

b. Applicable Federal Air Standards and Control Plans

(1) Ambient Standards

As required by the Clean Air Act of 1970, the EPA has promulgated primary air quality standards which are intended to protect human health with an adequate margin of safety, and secondary air quality standards which are intended to protect public welfare. These standards apply to sulfur dioxide, suspended particulates, carbon monoxide, photochemical oxidants, non-methane hydrocarbons and nitrogen dioxide. Both long and short-term maximum permissible levels are specified. These standards are summarized in Table V-2. Compliance with these standards will be obtained by proper consideration of meteorological (dispersion) parameters in the detailed engineering design of all stacks or other potential emission sources and by fuel management policies.

(2) Non-deterioration Regulations

The EPA recently promulgated plans intended to prevent significant air quality deterioration. These plans provide for the designation of geographical areas with different allowable increments of air pollution, as summarized in Table V-3. All areas are initially classified as "Class II" unless reclassified otherwise under EPA approved procedures. Those procedures permit reclassification only after public hearings have been held in the regions which would be affected by such change.

Another provision of the non-deterioration regulations calls for a review by the EPA of selected types of new sources, including petroleum refineries and fuel conversion plants. As part of this review, the EPA must evaluate air pollution control technology to be utilized by the proposed new source, and must prescribe emission limitations or equipment standards which will correspond to the use of "best available technology" for control of particulates and sulfur dioxide.

(3) New Stationary Source Performance Standards

The EPA has promulgated New Stationary Source Performance Standards which prescribe design and operating requirements for certain categories of new sources. The State of Colorado has incorporated the standards for all but one of these categories into its regulations. These New Stationary Source Performance Standards will be discussed below under Colorado Regulation No. 6 . In addition, EPA has also promulgated performance specifications for continuous monitors. These have not yet been incorporated into Colorado Regulation No. 6.

The EPA New Stationary Source Performance Standards for petroleum storage vessels were not specifically included under Colorado regulations. These standards set the true vapor pressure of any petroleum liquid under actual storage conditions which are allowed for vessels of specified designs. Monitoring requirements are also specified and are discussed in Section VI.E., Monitoring Programs.

(4) National Emission Standards for Hazardous Pollutants

Emission standards for hazardous pollutants such as asbestos, beryllium and mercury have been established. Other pollutants may eventually be controlled by these standards.

c. Applicable Colorado Air Standards and Control Plans

Table V-2 FEDERAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time[a]	Primary Standards[b]	Secondary Standards[c]
Sulfur Dioxide	Annual arithmetic mean	80 $\mu gm/m^3$ (0.03 ppm)	---
	24 hr.	365 $\mu gm/m^3$ (0.14 ppm)	---
	3 hr.	---	1300 $\mu gm/m^3$ (0.5 ppm)
Suspended particulate matter	Annual geometric mean	75 $\mu gm/m^3$	60 $\mu gm/m^3$
	24 hr.	260 $\mu gm/m^3$	150 $\mu gm/m^3$
Carbon monoxide	8 hr.	10 mg/m^3 (9 ppm)	Same as primary standard
	1 hr.	40 mg/m^3 (35 ppm)	
Photochemical oxidants (corrected for NO_2 and SO_2)	1 hr.	160 $\mu gm/m^3$ (0.08 ppm)	Same as primary standard
Hydrocarbons (corrected for methane)	3 hr. (6 to 9 a.m.)	160 $\mu gm/m^3$ (0.24 ppm)	Same as primary standard
Nitrogen dioxide	Annual arithmetic mean	100 $\mu gm/m^3$ (0.05 ppm)	Same as primary standard

a. The 1-, 3-, 8-. and 24-hour standards are maximum concentrations not be exceeded more than once per year.

b. Primary standards are intended to protect public health.

c. Secondary standards are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

Table V–3 FEDERAL NON-DETERIORATION STANDARDS

Allowable Increments, $\mu g/m^3$

	Class I	Class II
Particulate Matter:		
Ann. Geom. Mean	5	10
24-Hour Maximum	10	30
Sulfur Dioxide:		
Ann. Arith. Mean	2	15
24-Hour Maximum	5	100
3-Hour Maximum	25	700

Class III

Concentrations limited to those prescribed by National Ambient Air Quality Standards.

Various standards and regulations have been adopted by the Colorado Air Pollution Control Commission (APCC) and are administered by the Air Pollution Control Division (APCD) of the Colorado Department of Health. Those regulations which would apply to shale oil operations are discussed below.

(1) Ambient Standards

The State of Colorado has adopted ambient air quality standards for particulates and sulfur dioxide, described as follows:

Particulates. Standards for suspended particulate matter as absolute values are defined for "designated" and "non-designated" areas as shown in Table V-4. The Piceance Creek basin is currently a non-designated area.

Sulfur Dioxide. Under revised standards recently passed by the Colorado APCC, allowable increments of SO_2 concentration are defined for three different categories as indicated in Table V-5. Under the revised standards, all areas of the state, except the Eastern Slope metropolitan areas and Mesa County, are initially classified as Category I, until reclassified by the APCC. Reclassification is initiated by petition to the APCC.

As with the federal ambient standards, compliance will be achieved by proper design of stacks and air pollution control equipment and by fuel management, coupled with interpretations of diffusion models.

(2) Regulation No. 1

Emission standards for opacity, fugitive dust, particulates and sulfur oxides are covered by "Regulation No. 1" of the Colorado Air Pollution Control Commission. Opacity is limited to 20% for stationary sources. Fugitive dust will be minimized by specified procedures, including but not limited to:

- watering, addition of dust palliatives or penetration chemicals (e.g. Lignin sulfonate, "Crust 500"), and by graveling and paving of roads and parking areas

- wetting down, prewatering, landscaping, revegetation and use of dust palliatives or chemical suppressants in the case of earthmoving activities. See Section V.K., Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas

- use of sequential blasting, where feasible

- frequent washing down of hauling equipment

- minimization of topsoil disturbance, accompanied by reclaiming as soon as possible

Table V–4 AMBIENT AIR STANDARDS FOR METROPOLITAN DENVER AIR QUALITY CONTROL REGION, AIR QUALITY CONTROL AREAS, AND THE STATE OF COLORADO

Suspended Particulate Matter

Suspended Particulate Matter: (a)
(Micrograms Per Cubic Meter - $\mu g/m^3$)

	Non-Designated Areas	Metro-Denver Air Quality Control Region, and Designated State Areas 1973	1976	1980
Short Term(b)	150	200	180	150
Long Term(c)	45	70	55	45

(a) Measured at ambient conditions.

(b) Short term level - A 24-hour maximum of any 24-hour period and must not be exceeded more than once in a 12-month period.

(c) Long term level - An annual arithmetic mean of all 24-hour concentrations.

Table V–5 AMBIENT AIR STANDARDS FOR THE STATE OF COLORADO

Sulfur Dioxide (SO_2)

(Micrograms per cubic meter [$\mu g/m^3$])

	Maximum Allowable Increments ($\mu g/m^3$)		Maximum Allowable Concentrations ($\mu g/m^3$)
	Sulfur Dioxide Category I (formerly non-designated areas)	Sulfur Dioxide Category II	Sulfur Dioxide Category III (formerly designated areas)
Annual Mean	3 (.001)	15 (.005)	60 (.021)
24-hr. max.	15 (.005)	100 (.035)	260* (.091)
3-hr. max.	75 (.026)	700 (.245)	1300* (.455)

( ) = equivalent values in parts per million (1 ppm=2860 $\mu g/m^3$ at O°C and 760 mm Hg [Torr]).
* Not to be exceeded more than once in a twelve-month period.

On the effective date of this amended Ambient Air Standard for Sulfur Dioxide, all Non-designated Areas of the State of Colorado are deemed to be Sulfur Dioxide Category I areas and all Designated Areas and the Denver Air Quality Control Region are deemed to be Sulfur Dioxide Category III areas.

Maximum Allowable Increments – means the sum of allowable increments in sulfur dioxide over baseline sulfur dioxide concentrations for any source or combination of sources constructed after the effective date of these standards.

Maximum Allowable Concentration – means the level above which no new source of sulfur dioxide would be permitted.

- covering of conveyors and haulage equipment, where applicable

- use of water sprays or dust collectors at transfer points

- proper wetting and compaction of processed-shale disposal embankments, followed by revegetation. See Section V.G., Overburden Management, and Section V.H., Processed-shale Disposal

Although Regulation No. 1 includes formulae for determining maximum allowable emission rates of particulates and SO_2 from point sources, these are superceded in part by Regulation No 6, discussed below. Regulation No. 6 includes specific control procedures for those portions of the processing complex which would be classified as a "petroleum refinery." Control equipment for particulate emission sources will include both wet collectors (scrubbers) and dry collectors (bag filters, cyclones). For the more significant sources, a combination of these may be used. For an example, see Section IV.E.1., Pyrolysis and Oil Recovery, describing preheat systems.

Sulfur dioxide emissions will be controlled by fuel treating (e.g. absorbtion of hydrogen sulfide from process fuel gases).

(3) Regulation No. 2

Colorado's Regulation No. 2 applies to odorous air contaminants. The shale-oil related aromas which may exist at the proposed processing site comply with this regulation because of their localized nature and the control technology which will be utilized throughout the plant.

(4) Regulation No. 3

Colorado's Regulation No. 3 requires that an "air contaminant emission notice" describing each anticipated emission source be filed prior to the release of any air contaminant. It also requires that an "emission permit" be obtained prior to construction and/or operation of an air contaimination source. In order for the permit to be granted, the APCD must ascertain that applicable regulations will not be violated and acceptable "halt and curtailment" procedures will be defined to assure that applicable ambient air quality standards will not be exceeded even under adverse meteorological conditions.

In the event of an air pollution alert, warning or emergency episode a number of procedures will be followed to reduce emissions. Preferred procedures at any given time would depend upon existing inventories of crushed oil shale and intermediate products.

Particulates. If particulate concentrations were excessive, reduction would be obtained by one or more of the following alternatives:

- maximum feasible application of water to storage and disposal piles

- maximum feasible application of water or dust suppressant to roads

- curtailment of mining, crushing, and retorting operations

Sulfur Dioxide. If sulfur dioxide concentrations were excessive, reduction would be obtained by one or more of the following alternatives:

- switching to a fuel with a lower sulfur content

- curtailing combustion in retorting and upgrading operations

Nitrogen Oxides. If nitrogen oxide concentrations were excessive, reduction would be obtained by one or more of the following alternatives:

- possibly switching to a "cleaner" fuel

- curtailing mobile source activity

- curtailing combustion in retorting and upgrading operations

Hydrocarbons. If hydrocarbon concentrations were excessive, reduction would be obtained by one or more of the following alternatives:

- balancing storage tank levels and curtailing hydrocarbon loading operations

- curtailing mobile source activity

- curtailing retorting and upgrading operations

Carbon Monoxide. If carbon monoxide concentrations were excessive, reduction would be obtained by curtailing mobile source activity.

The reduction of operations below turndown level would result in eventual shutdown. Since shutdowns and start-ups are times of maximum emissions, a careful evaluation will be made before a decision is reached to reduce operations, especially for short periods of times.

(5) Regulation No. 6

Colorado's Regulation No. 6 defines standards of performance for selected new stationary sources, including large fossil-fuel-fired steam generators and petroleum refineries. The standards for steam generating operations apply to units of "more than 250 million Btu/hr. heat input." This section is potentially applicable but it is considered unlikely that generating units of this size will be required by the proposed operations.

The standards relating to petroleum refineries require that process fuel gases be treated to contain less than 0.10 grain/dry scf of hydrogen sulfide in order to control SO_2 emissions. Compliance can be achieved through the use of diethanolamine (DEA) treating. Monitoring procedures are also prescribed in Regulation 6 for certain types of emission sources; these are discussed in Section VI.E., Monitoring Programs. Recent amendments to these have been promulgated by EPA.

(6) Regulation No. 7

Regulation No. 7 of the Colorado APCC controls the emission of hydrocarbon vapors. This regulation defines acceptable methods for such activities as the storage and transfer of solvents. Those parts which apply to "non-designated" areas (including Piceance Creek basin) would probably not be applicable to shale oil processing facilities. If the Piceance Creek basin were to become a "designated" area, then methods would be specified for the storage of various "petroleum distillates" such as product and intermediate shale oil fractions. The use of floating roof tanks and other such standard control measures would be required for storage, and vapor recovery systems would be required for specified "transfer operations."

(7) Regulation No. 8

Colorado's Regulation No. 8 controls emissions of approximately 500 "chemical substances and physical agents," including those covered by the federal "National Emission Standards for Hazardous Pollutants." This regulation would apply to the proposed shale oil operations if any of the designated air contaminants are emitted.

d. Diffusion Modeling Program and Predicted Ambient Concentrations

(1) Diffusion Modeling Program

In addition to the plans and procedures described above, the Lessee will conduct a diffusion modeling program to evaluate the ambient concentrations of pollutants which may occur from project activities. That program is described as follows:

Stage I (1975)

(a) Stationary Source Emissions

A Gaussian plume model as given by Turner, 1970 (Turner, D. B., 1970: Workbook of Atmospheric Dispersion Estimates, U. S. Dept. HEW, PB 191482.) has been used to estimate pollutant concentrations of total suspended particulates (TSP), sulfur dioxide (SO_2), total hydrocarbons (THC) and nitrogen oxides (NO_x) from major stacks.

As input to the model, concentrations from the proposed stacks have been determined quarterly based on the following information:

- Average hourly values of wind speed, wind direction, temperature and atmospheric stability at the 200-foot level of the meteorological tower for October 1974, and January, April and July 1975, as representive (average) months in each quarter.

- Only major stacks were considered and were assumed to be concentrated at one geographical location.

- Plume rise utilized the Briggs formulation as given by Briggs, 1969 (Briggs, G. A. 1969: Plume Rise, USAEC Office of Info. Serv.) and Turner, 1973 (Turner, D. B., 1973: Dispersion Estimate Suggestion Number 2 (revised), EPA Model Applications Branch.).

- Twenty-four hour averages were obtained from averaging the hourly results over a 24-hour period.

- Annual averages were examined by using ranges from the quarterly averages.

- Only the hydrotreated shale oil plant burning raw shale oil case has been analyzed.

(b) Vehicle Emissions

Emissions from vehicular traffic were examined utilizing box models for the following cases:

- Two segments of Piceance Creek road from the Tract C-a turnoff at Ryan Gulch to the P-L Ranch entrance to Tract C-b and from the start of the Piceance Creek valley on the east to the P-L Ranch entrance to Tract C-b.

- For the years 1973 to 1990, existing EPA Document AP-42 and State of Colorado vehicular emission estimates for NO_x, CO, and THC in grams per mile were utilized. Speed correction factors for automobiles were applied for high altitudes. No speed correction factors were available for heavy duty diesel trucks.

- Emission rates in grams per hour per box model were estimated from the number of vehicle miles in each road segment.

- Three representative inversion heights (150, 250 and 400 feet) and two wind speeds (2 and 6 mph) were assumed for conditions in the Piceance Creek road segments.

- For the six combinations of wind and inversion heights developed for the box model and predicted emission rate in grams per hour, total pollutant concentrations in micrograms/cubic meter were calculated and plotted for 1-hour and 10-hour time periods.

- The plots of wind and inversion heights can be used to determine ambient concentrations for any traffic volumes.

Stage II (1976-1979)

(a) Experimental Investigations

More sophisticated modeling will be undertaken during Stage II as additional data are collected. Program components presently planned include:

- First year of AQ/meteorological data collection will be completed by November 1, 1975. Such data collection will be continued the second year with a few exceptions. The first year's data, including atmospheric stability assessments, will be used as imputs to an improved diffusion model as a "representative year."

- The feasibility of wind tunnel diffusion studies using small scale rough-terrain models will be investigated.

- A more detailed wind-flow pattern analysis via an expanded monitoring network of ground level meteorological stations will be made.

- A computer model is now available which predicts the local wind patterns over rough terrain in the presence of thermal gradients and will be considered. At present, this model needs verification, validation and further development. This model will probably be verified in 1976.

- Correlations between various wind flow analyses will be made.

- Field tracer experiments utilizing ground or airborne monitoring stations will be made.

- Correlations between wind flow analyses and tracer experiments will be made.

(b) Model Development

- Multiple point-source diffusion models over rough terrain will be developed.

- Plant emission characteristics will be updated and refined.

- Computer models will be verified.

(c) Model Utilization

- Atmospheric diffusion of plant emissions will be predicted for averaging times consistent with air quality standards. Concentration isopleths will also be obtained.

- Models will be utilized in plant design, including opera ting strategy, where feasible.

- The possibility of further transportation analyses over that conducted in Stage I will be investigated.

- The possibility of utilizing models for long-term disposition studies (pine, lichen, grasses) will be investigated. Specific methodology needs further definition, although computation of cumulative pollutant isopleths at specific geographic locations of various species appears to offer promise.

- A detailed stack emission monitoring plan will be finalized.

(2) Retorting and Upgrading Facilities

The form of the Gaussian plume equation utilized for analysis of diffusion from the stack emission in Phase I is that given by Turner, 1970 (his eq. 3.1):

$$\chi(x,y,z;\ H) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

where:

χ	= concentration (g/m^3)
Q	= stack emission rate (g/sec)
u	= mean wind speed (m/sec)
x	= downstream distance from the point source (m) (in direction of mean wind)
y	= horizontal distance, perpendicular to x, (m)
z	= vertical distance upward from the base of the stack (m)
H	= effective stack height = $h + \Delta H$
h	= physical stack height (m)
ΔH	= plume rise (via Briggs formulation) (m)

σ_y, σ_z = standard deviations of plume concentration distributions in the horizontal and vertical directions, respectively. (σ_y and σ_z are plotted as Figs. 3-2 and 3-3 in Turner, 1970, as functions of downwind distances (x) and Pasquill-Gifford stability classifications.

Estimates based on the Gaussian plume model have generally proven to be conservative. The model also has certain shortcomings when applied to rough terrain. However, it is the best model available at the present time.

Average hourly values of wind speed, wind direction and atmospheric stability for one "representative" month of each quarter (Table V-6) are utilized as inputs for Phase I. Calculations of X for each gaseous constitutent are then readily obtained for fixed receptor locations and grid points at 0.5-km and 1.0-km intervals after geometrically relating receptor location to the hourly plume center line direction. The stack emission characteristics for the major stacks are given in Table V-7 for the hydrotreated shale oil case.

Utilizing the meteorological inputs shown on Table V-6 and the stack emission characteristics of Table V-7, hourly concentrations of sulfur dioxide (SO_2), oxides of nitrogen (NO_x), total hydrocarbons (THC), and particulate matter (PM) have been determined from the Gaussian plume model. Concentration values in micrograms/cubic meter are calculated on both 0.5-km and 1.0-km rectangular grids. One such grid is presented of Figure V-1 showing typical hourly average concentrations for SO_2. The one-hour concentrations were then used to develop 24-hour (or daily averages) for the "average day of the average month" for each quarter. Typical 24-hour averages are presented for SO_2 for the four seasonal quarters at 0.5-km grid spacing on Figures V-2 to V-5.

Results for maximum 24-hour values obtained from this preliminary Stage I study are presented in Table V-8. They indicate maximum increments of 9 $\mu g/m^3$ for SO_2, 34 $\mu g/m^3$ for NO_x, 5 $\mu g/m^3$ for THC and 19 $\mu g/m^3$ for PM. Annual mean concentrations should be well below the peak values in this table. At this time, with only preliminary data available, neither a more elegant model nor a more in-depth examination to predict short-term peaks appears justified. However, from the brief cases examined, the best estimate is that compliance with federal and state standards is achievable. In Phase II this entire modeling process is to be repeated in more depth.

(3) Access Corridors

Vehicular emissions are analyzed in the access corridors leading to Tract C-b, specifically for segments of Piceance Creek road from the Tract C-a turnoff to the P-L Ranch and from the start of Piceance Creek valley (on the east) to the P-L Ranch (Figure V-6). A simple "box" model was used to predict concentrations of NO_x, CO and THC in two

Table V–6 AVERAGE HOURLY METEOROLOGICAL VALUES BY QUARTER*

(Inputs to Stage I Modeling)

Item	Units	Quarter ("Representative" Month)	Average Hourly Value																							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Wind Speed	MPH		8	8	8	7	7	7	6	5	5	7	8	10	15	13	13	10	9	9	8	9	9	9	8	7
Wind Dir.	Deg	Oct '74	163	182	270	270	181	211	192	200	211	132	289	282	270	262	286	287	280	287	294	214	183	183	182	174
Rel. Hum.	%		61	61	62	63	64	64	63	64	63	60	57	55	53	52	49	51	50	52	56	58	60	60	62	64
Temp.	°F		43	43	42	42	41	41	41	41	44	48	51	53	55	56	55	55	54	54	51	49	47	46	45	43
Stability	Class		D	D	D	E	D	D	E	E	F	F	E	E	E	E	E	E	E	E	D	E	E	D	E	D
Wind Speed	MPH		9	9	9	9	10	10	9	10	10	10	11	11	14	12	11	12	11	11	9	8	9	9	9	9
Wind Dir.	Deg		226	226	217	90	90	90	90	234	229	242	90	258	260	272	265	245	231	244	219	229	239	203	207	219
Rel. Hum.	%	Jan '75	71	72	72	73	74	75	76	76	75	70	65	61	59	60	57	57	60	63	65	65	68	69	70	71
Temp.	°F		21	20	20	20	20	20	20	20	21	23	26	28	30	29	28	29	27	25	24	23	23	22	22	22
Stability	Class		D	D	D	D	D	D	D	D	E	E	E	E	E	E	E	E	E	D	D	D	D	D	D	D
Wind Speed	MPH		8	8	9	9	10	10	10	10	12	13	15	15	15	15	16	16	15	14	12	12	11	10	10	8
Wind Dir.	Deg		236	241	270	90	90	90	90	244	254	233	90	235	237	237	236	234	234	234	216	199	211	221	224	229
Rel. Hum.	%	Apr '75	70	72	73	74	75	75	75	75	72	67	64	61	58	56	55	54	55	58	60	62	64	66	66	67
Temp.	°F		31	30	30	29	28	28	28	29	31	33	34	36	37	39	39	40	39	38	37	36	35	34	33	32
Stability	Class		D	D	D	D	D	D	C	B	B	B	A	A	A	A	A	A	A	B	C	D	D	D	D	D
Wind Speed	MPH		6	6	6	6	6	7	7	8	8	9	10	10	10	10	10	10	9	9	9	8	7	7	6	6
Wind Dir.	Deg		194	183	173	163	152	142	156	170	183	197	211	225	226	227	228	230	231	232	227	223	218	213	209	204
Rel. Hum.	%	July '75	61	61	61	62	62	62	61	59	58	57	55	54	54	53	53	52	52	51	53	54	56	57	59	60
Temp.	°F	(estimated)	45	45	44	44	43	42	44	45	47	48	50	51	52	53	54	55	56	58	56	54	52	50	48	46
Stability	Class		D	D	D	D	D	D	D	C	C	C	B	B	B	C	C	C	C	D	D	D	D	D	D	D

*Wind speed, direction, and relative humidity at 200 foot level of meteorological tower. Stability classes estimated from the temperature difference between the 30 foot and 200 foot levels on the meteorological tower.

Table V–7 STACK EMISSION CHARACTERISTICS – HYDROTREATED SHALE OIL CASE

					Emission Rate (gm/sec)			
Stack	Height (m)	Radius (m)	Temperature (°K)	Velocity (m/s)	SO_2	NO_x	THC	PM
Pyrolysis and Oil Recovery Unit:								
Preheat System	95	1.5	350	15	7	180	35	35
Steam Superheater - Ball Circulation System	95	1.0	375	15	12	15	–	30
Processed Shale Moisturizing System	95	1.0	500	15	–	–	–	35
Hydrogen Furnace	25	1.0	500	15	4	10	–	2
Sulfur Plant	65	1.0	400	10	10	–	–	–

All numbers are approximate

PICEANCE CREEK BASIN   LEASE TRACT C-B

APRIL 1975

HOURLY AVERAGE FOR HOUR 11.   WIND SPEED 15. MPH.   DIRECTION 90. DEGREES.   TEMPERATURE 34. DEG F.   STABILITY CLASS 1.

SO2 UNITS ARE MICROGRAMS PER CUBIC METER   GRID SPACING IS 0.5 KM   x - denotes source of emissions

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	2	4	15	61	x	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure V–1 TYPICAL HOURLY AVERAGE CONCENTRATIONS FOR SO_2: APRIL, 1975

PICEANCE CREEK BASIN LEASE TRACT C-a

24 HOUR AVERAGE GROUND LEVEL CONCENTRATIONS OF SO2 FOR

OCTOBER 1974

SO2 UNITS ARE MICROGRAMS PER CUBIC METER GRID SPACING IS 0.5 KM

x - denotes source of emissions

0	0	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure V–2 24 HOUR CONCENTRATIONS FOR SO_2: OCTOBER, 1974

PICEANCE CREEK BASIN   LEASE TRACT C-B

24 HOUR AVERAGE GROUND LEVEL CONCENTRATIONS OF SO2   FOR

JANUARY 1975

SO2 UNITS ARE MICROGRAMS PER CUBIC METER   GRID SPACING IS 0.5 KM   x - denotes source of emissions

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2	1	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	1	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	2	2	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	2	2	2	2	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	2	2	2	2	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	3	3	2	2	1	1	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure V–3   24 HOUR CONCENTRATIONS FOR SO_2: JANUARY, 1975

PICEANCE CREEK BASIN LEASE TRACT C-B

24 HOUR AVERAGE GROUND LEVEL CONCENTRATIONS OF SO2 FOR

APRIL 1975

SO2 UNITS ARE MICROGRAMS PER CUBIC METER

GRID SPACING IS 0.5 KM

x - denotes source of emissions

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	2	1	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	7	2	1	0	0	0	0	0	0	0	0
3	3	3	3	3	3	2	2	2	1	1	2	x	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure V–4 24 HOUR CONCENTRATIONS FOR SO_2: APRIL, 1975

PICEANCE CREEK BASIN LEASE TRACT C-b

24 HOUR AVERAGE GROUND LEVEL CONCENTRATIONS OF SO_2 FOR

JULY 1975 (ESTIMATED)

SO_2 UNITS ARE MICROGRAMS PER CUBIC METER GRID SPACING IS 0.5 KM

x - denotes source of emissions

0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1	2	2
0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	2	2	2
0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	2	3	3	2	2
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	3	3	3	1	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	4	4	3	1	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	4	4	3	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	5	5	2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	6	6	2	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	8	6	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	4	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure V–5 24 HOUR CONCENTRATIONS FOR SO_2: JULY, 1975 (estimated)

Table V–8 PROJECTION OF AMBIENT CONCENTRATIONS OF POLLUTANTS

Pollutant	Location	Concentration, 24-Hour Maximum Values ($\mu g/m^3$) "Representative" Month Oct. '74	Jan. '75	Apr. '75	July '75
SO_2	On Tract	0	1	7	9
	Near Tract Boundary	0	1	2	6
	Off Tract	2	3	3	6
NO_x	On Tract	0	1	35	34
	Near Tract Boundary	0	1	7	11
	Off Tract	10	12	10	28
THC	On Tract	0	0	5	5
	Near Tract Boundary	0	0	1	4
	Off Tract	1	1	1	4
PM	On Tract	0	1	19	19
	Near Tract Boundary	0	1	4	15
	Off Tract	3	7	6	15

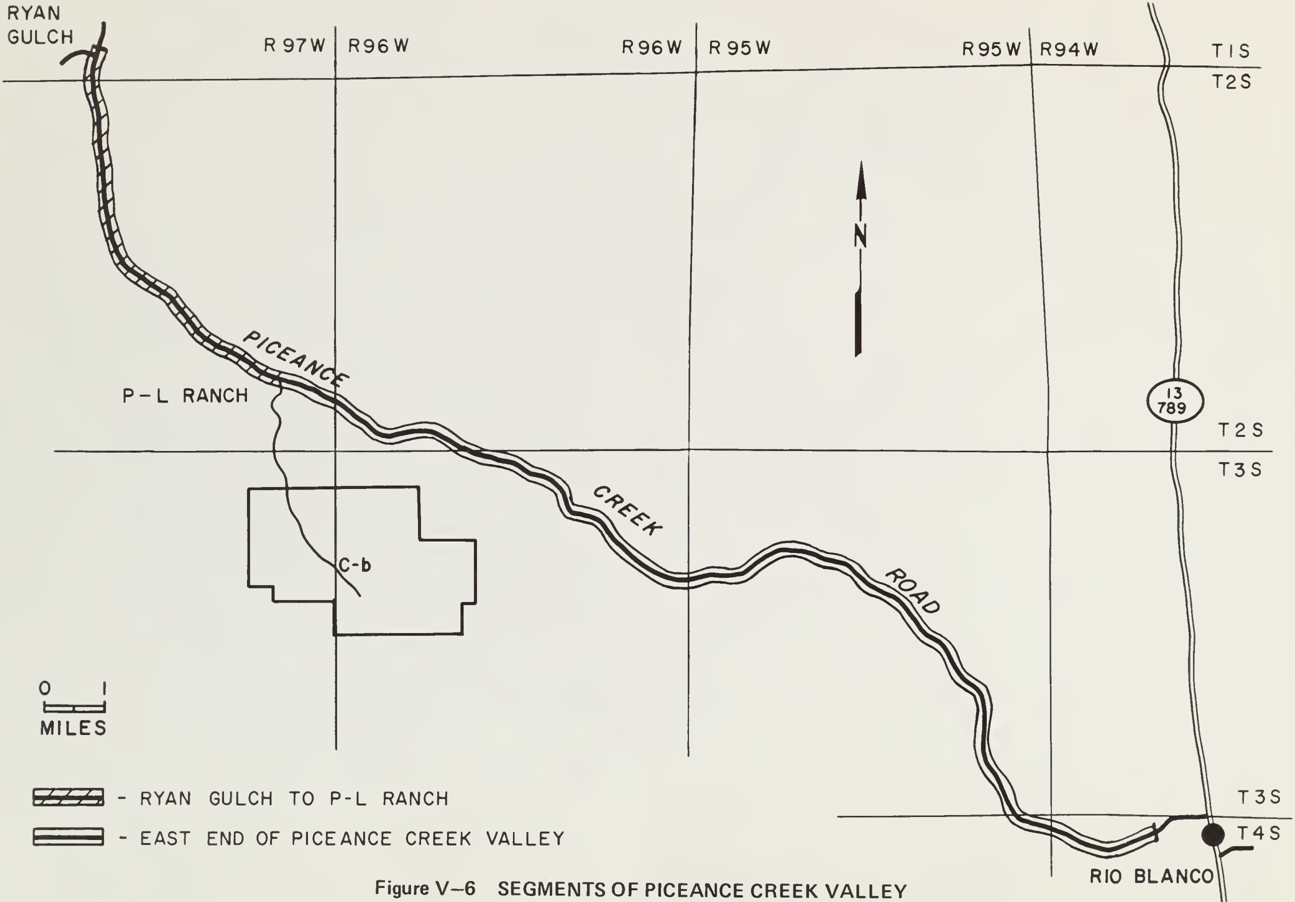


Figure V–6 SEGMENTS OF PICEANCE CREEK VALLEY USED IN BOX MODEL ANALYSIS portions of the Piceance Creek valley for three inversion heights (150, 250 and 400 feet) and two wind speeds (2 and 6 mph). Figures V-7 to V-9 illustrate the concentrations reached at the end of 1 hour for NO_x, CO, and THC, respectively, in the east end of Piceance Creek valley to the P-L Ranch. Similar concentrations for the portions of Piceance Creek valley from Ryan Gulch to the P-L Ranch are given on Figures V-10 through V-12.

Using the emissions rates given previously of 52,700 gm/hr for NO_x, 987,000 gm/hr for CO, and 73,900 gm/hr for THC, Figures V-7 to V-9 can be used to predict maximum incremental concentrations (using assumed values of 6 mph wind speed and 150-foot inversion height), at the end of one hour and in the eastern end of Piceance Creek valley, of 80 $\mu g/m^3$ for NO_x, 1800 $\mu g/m^3$ for CO, and 130 $\mu g/m^3$ for THC. These estimated concentrations are conservative, since the actual time of travel for a vehicle averaging 35 mph in the 21-mile eastern portion of Piceance Creek valley is only 36 minutes.

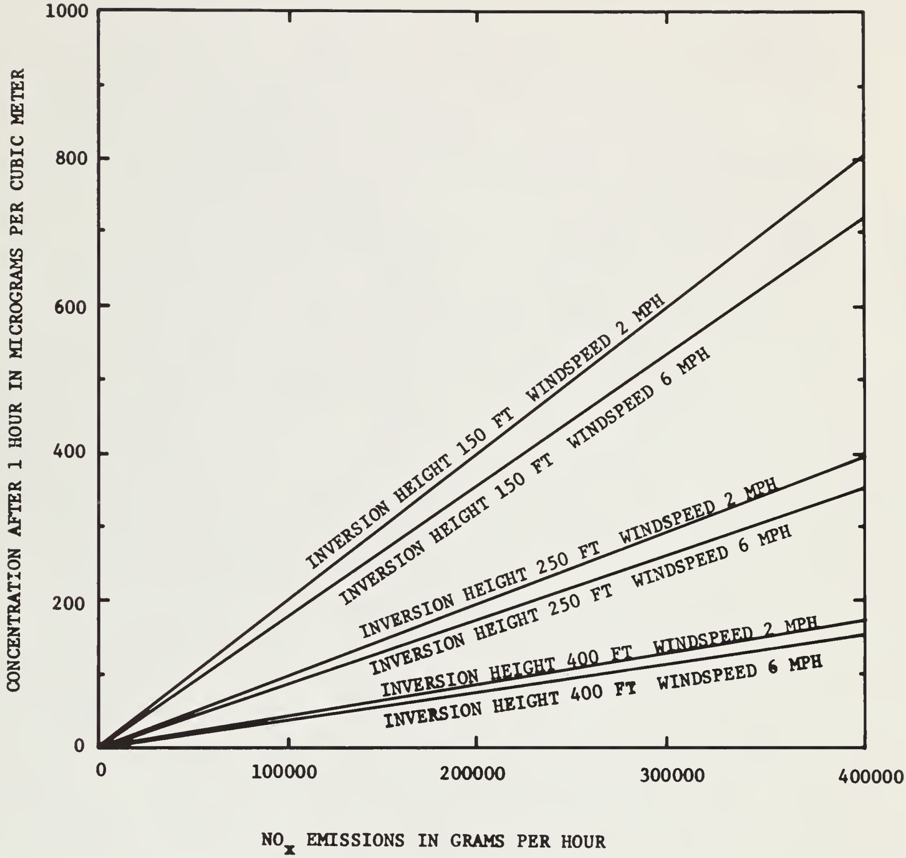


Figure V–7 BOX MODEL RESULTS FOR NO_x, EAST END OF PICEANCE CREEK VALLEY

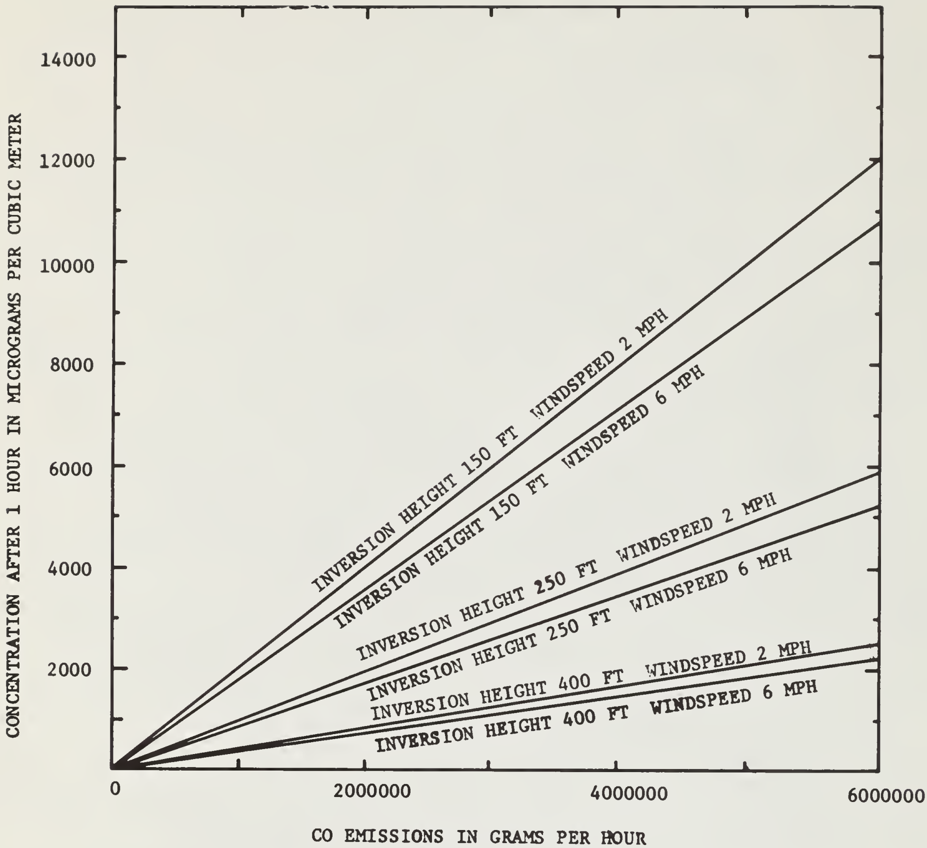


Figure V–8 BOX MODEL RESULTS FOR CO,
EAST END OF PICEANCE CREEK VALLEY

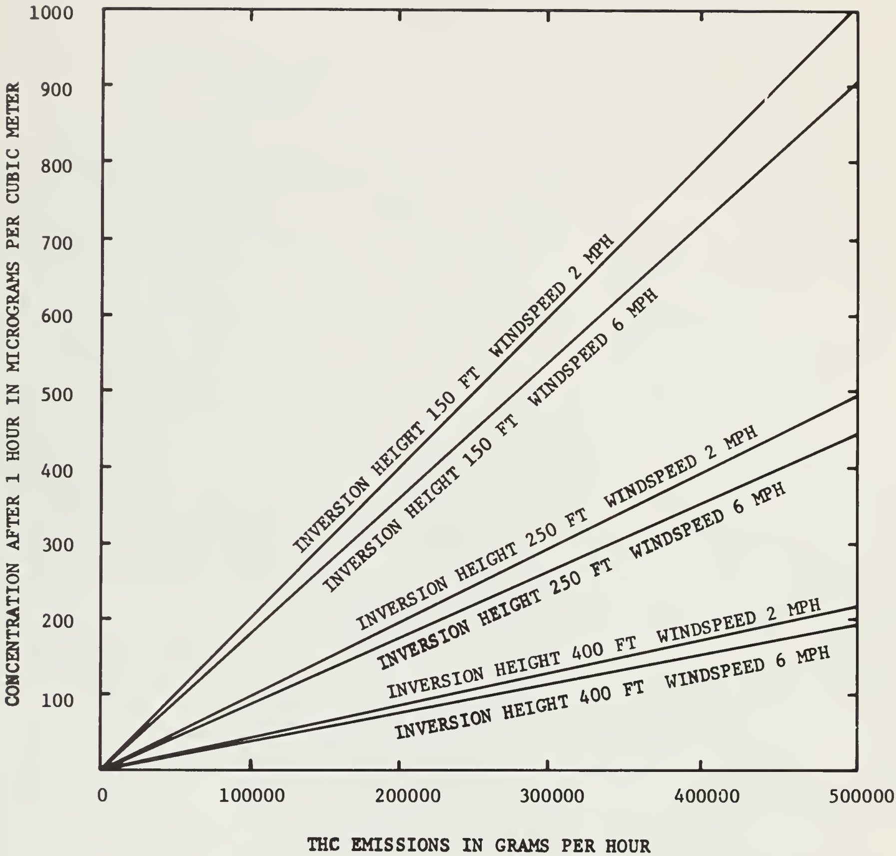


Figure V–9 BOX MODEL RESULTS FOR TOTAL HYDROCARBON, EAST END OF PICEANCE CREEK VALLEY

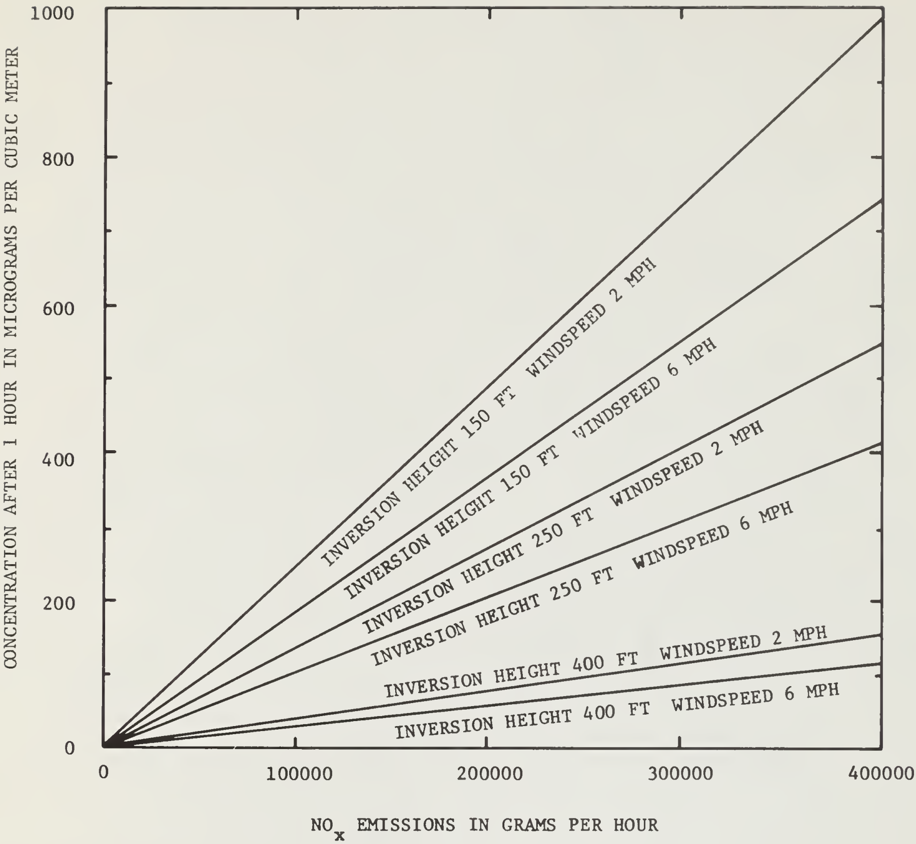


Figure V—10 BOX MODEL RESULTS FOR NO_x, RYAN GULCH TO P-L RANCH

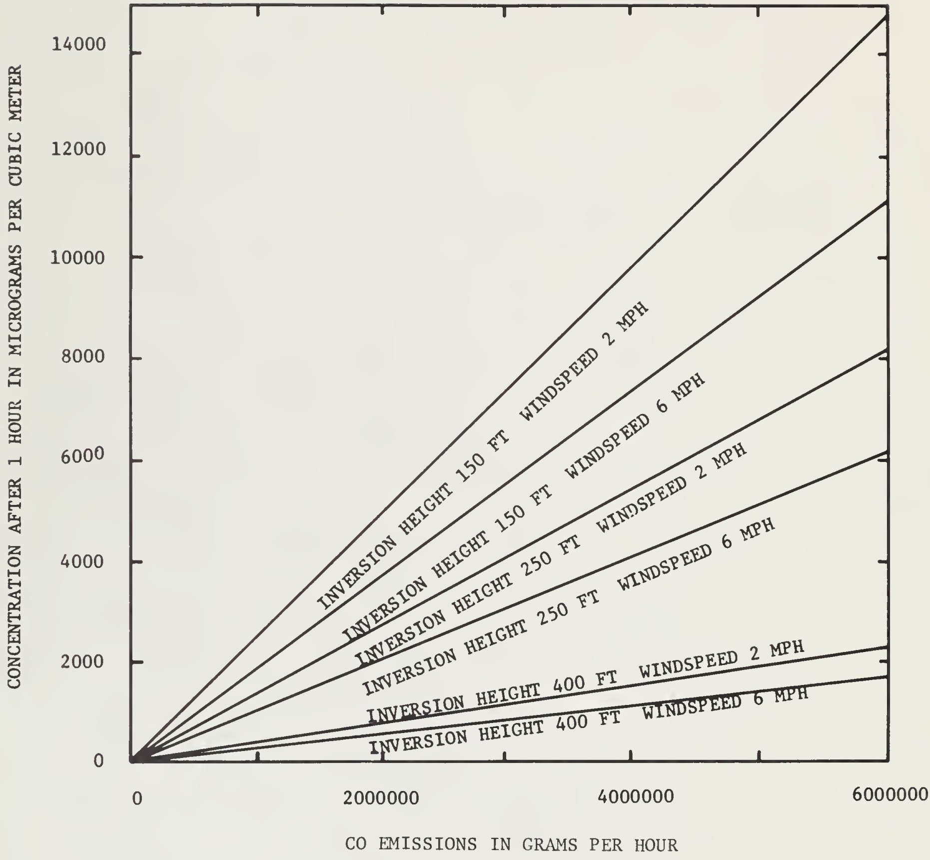


Figure V—11 BOX MODEL RESULTS FOR CO,
RYAN GULCH TO P-L RANCH

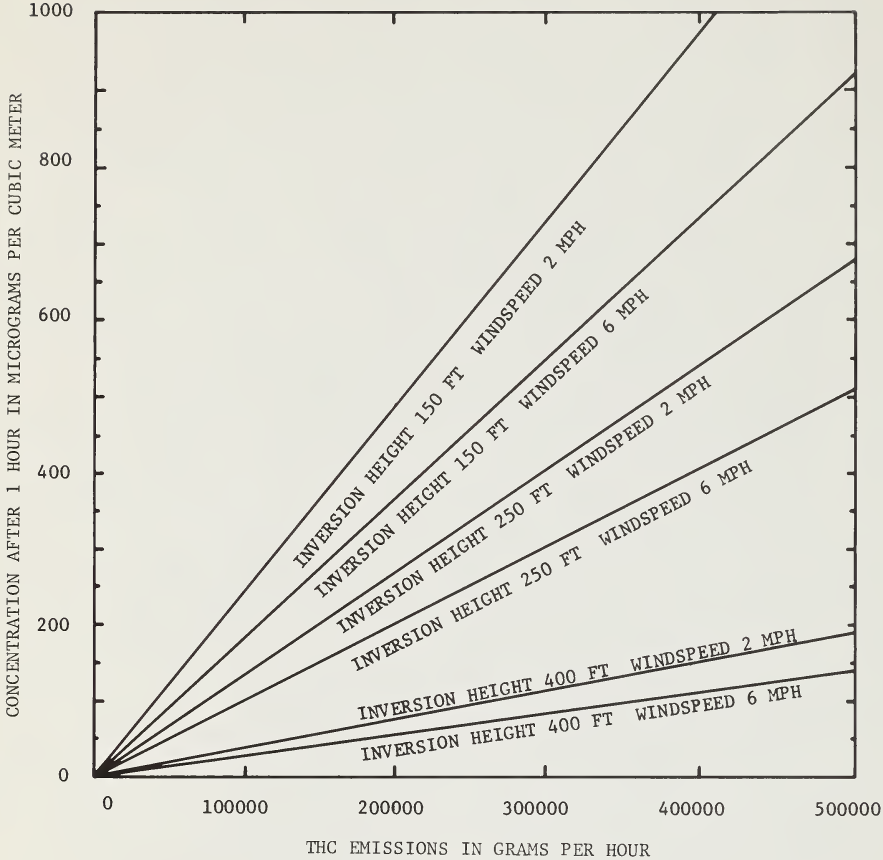


Figure V–12 BOX MODEL RESULTS FOR TOTAL HYDROCARBON, RYAN GULCH TO P-L RANCH

Water Pollution Control

Water Pollution Control

V. B. Water Pollution Control

1. Proposed Activities Affecting Water Quality

2. Lease Requirements, Applicable Law and Regulations and Control Plans

   a. Construction
   b. Mining
   c. Processing Facilities
   d. Processed-shale Disposal
   e. Supporting Off-tract Facilities

B. Water Pollution Control

This plan has been prepared to evaluate activities which may contribute to water pollution, to review applicable Lease provisions, laws and regulations, and to set forth a procedure which will be followed by the Lessee to assure compliance with appropriate requirements.

1. Proposed Activities Affecting Water Quality

The potential for water pollution is present in all phases of activity. The major activities and facilities proposed in the DDP which could affect water quality are: 1) construction, 2) mining, 3) processing facilities, 4) processed-shale disposal, and 5) off-tract facilities. These are described in detail in Sections II, III and IV. Any land surface modifications associated with construction and operation could cause an increase in stream sediment load. Low-quality ground water produced by dewatering of the shaft and development mine (if allowed to escape) could degrade stream water quality. Likewise, effluents from the mine shop and plant facilities could cause stream pollution. Uncontrolled runoff from the processed-shale disposal area, with a high concentration of sediment and dissolved solids, could enter the surface water system. Off-tract activities could also produce contaminated effluents.

Plans for controlling these major potential sources of water pollution are described later in this section.

2. Lease Requirements, Applicable Laws and Regulations and Control Plans

Section 9 of the Stipulations requires that the Lessee carry out all operations on the Tract in compliance with federal, state and local laws and regulations. The project will be subject to a number of water quality laws and regulations including:

<u>Federal Water Pollution Control Act</u>. This act, and regulations adopted by EPA under its provisions, will require the preparation and implementation of oil spill contingency plans for storage tanks and pipelines, and a National Pollutant Discharge Elimination Systems (NPDES) permit for effluents leaving the plant. While the project is expected to be a net consumer of water, the uncertainties relating to mine water inflow may require controlled discharge to Piceance Creek. Such discharges would require a NPDES permit. A spill contingency plan for oil and hazardous materials is included in Section V. L. below.

<u>Colorado Water Control Act</u>. This law establishes stream water quality standards and regulates the discharge of pollutants into waters of the state. It is administered by the Water Quality Division of the Colorado Department of Health. This division also administers the NPDES permit programs.

Colorado Water Quality Control Commission. This commission and its support staff within the Colorado Department of Health administer and regulate the reinjection of water into underground disposal wells. Any disposal of water by reinjection will require public hearings and the approval of the commission.

The following plans and procedures will be implemented by the Lessee to avoid or minimize water pollution:

a. Construction

Most of the impacts on the surface hydrological regime during the construction phase will result from modifications of the land surface. Land modifications will include the development of the mine and plant sites, establishment of processed-shale and overburden disposal area, development of ore stockpiles, upgrading of existing roads, and construction of new roads, service corridors, dams and reservoirs. Without mitigation, these activities could increase both runoff and sediment loads in Sorghum Gulch, Cottonwood Gulch, Scandard Gulch and the unnamed gulch west of Cottonwood Gulch, all of which are tributary to Piceance Creek. While it is difficult to quantify these potential increases, they should be proportional to the acreage disturbed.

Increased stream sediment load will result from increased erosion of disturbed areas. In an effort to minimize erosion, the Lessee will utilize the erosion control and surface rehabilitation plans presented in Section V. K. In general, stream sediment load and siltation will be minimized by disturbing vegetation and the soil mantle as little as possible, contour-grading disturbed areas, installing catchments, and by initiating restoration activities as soon as feasible. The dams across Sorghum Gulch and Cottonwood Gulch will act as final sediment settling basins for the major construction sites.

Concentration of total dissolved solids (TDS) in runnoff from a distrubed area will be higher than that from the original undisturbed area. The retention dams across Sorghum and Cottonwood gulches will prevent the entry of most of this runoff into Piceance Creek.

Areas which are devoted to storage of construction fuels and chemicals will be diked and spillage will be controlled. Sanitary sewage disposal during construction will be collected and treated in an aerobic treatment system, with disposal in leach fields or through sprinkler irrigation of vegetated areas.

Construction of the mine site, the processed-shale embankment, catchment dams and other facilities will cause redistribution of infiltration to the ground water system in the vicinity of Sorghum Gulch. This redistribution may alter existing subsurface water movement, but any alteration should not be serious since Sorghum Gulch contributes nominally to the ground water system.

b. Mining

Shaft sinking, mine development and commercial mining will require dewatering of strata which have communication with the mine zone. Because of the low vertical permeability of the Four Senators zone and other rich oil shale layers above the mine zone, only limited amounts of ground water from isolated strata above the mine are expected to be produced. Aquifers below the mine zone will also be retarded by impermeable aquitards beneath the mining interval.

Ground water produced by the dewatering of the shaft and development mine could potentially cause stream pollution if uncontrolled. The procedures that will be used to handle the water produced by the Phase I dewatering operations are described in detail in Section II. In the event that large quantities of water must be removed from the aquifers above the mine roof excess water will be disposed of by irrigation, reinjection, or defluoridation, as discussed in Section II.L.2.

Once the plant is in operation, subsurface water in excess of that used within the mine for dust control will be pumped out of the mine area and used within the processing plant and in moisturizing and revegetating processed shale at the disposal area.

During active operations all sanitary sewage from surface and underground facilities will be collected and treated in a package system. Treated effluent from the underground sewage system would be brought to the surface and combined with similar waste for use or disposal as described in Section V. I., Disposal of Other Wastes. Water from the shops which might contain hydrocarbons would be passed through a grease trap and then utilized for dust suppression.

Water used in crushing operations for dust suppression will be clarified to prevent plugging of spray nozzles. All water supplied to the crushing operation is expected to remain with the ore as it moves on the conveyor system.

c. Processing Facilities

These facilities include retorting units, fractionation unit, hydrotreating units, hydrogen plant, coker unit, by-product separation unit, utilities plant, and ancillary facilities. The key elements in water quality protection are cleansing or disposing of internal streams, drainage, sewage and other wastes. The water quality protection procedures for these facilities are described below.

Internal streams such as sour water would be stripped of noxious substances and applied to the processed shale. Drainage of "clean" areas such as office roof drainage and parking lots external to the plant, will be discharged into natural drainage channels. All areas susceptible to oil and chemical spills will drain into an oily-water sewer system and thence into a system consisting of a surge basin, API separator and guard pond. All drainage from the plant area will be directed toward the Sorghum Gulch reservoir as a contingency against exceeding the sewer capacity.

Cooling water and boiler blowdown, along with other waste streams, will be pumped to a tank in the retorting structure and applied as makeup water in the processed-shale moisturizer. This water will be applied to the processed shale to control dust and facilitate compaction of the material during disposal operations.

Sanitary sewage would be collected and treated in a package system. Effluent from the treatment system would be added to the processed shale. Also under consideration is a system to apply the effluent directly to the disposal-area revegetation plots in order to utilize the nutrients in the water.

In summary, all liquid streams will be utilized within the process except for clean runoff water which goes to natural drainages.

d. Processed-shale Disposal

As indicated above, all waste streams that cannot be utilized directly in ways which would avoid water quality degradation would be applied to the processed shale to raise the water content to about 14 weight percent, which is necessary for dust control and compaction. By utilizing waste streams, the necessity of additional diversion of higher quality water is avoided. The processed-shale disposal and revegetation procedures are described in Sections V. H. and V. K., respectively. As described in these sections, the water previously applied to the pile will be substantially contained in the pile. Infiltration of precipitation through the pile is expected to be non-existent except at shallow portions of the pile.

Runoff from the processed-shale embankment will contain higher concentrations of dissolved solids than runoff waters from undisturbed areas. A portion of the salts contained in the moisturized and compacted shale will migrate to the surface and crystallize on the surface in the form of a visible white crust during wetting and drying cycles. This crust will be primarily comprised of N^{+}, Mg^{++}, $SO_4^{=}$, and Cl^{-} ions with lesser amounts of $CO_3^{=}$ ions and other miscellaneous solids. Runoff from precipitation and irrigation for revegetation purposes will dissolve this crust and leach or flush other dissolved solids from the surface of the pile. These dissolved solids will be retained in the Sorghum Gulch reservoir and used as discussed below.

As discussed in Section V. K., Erosion Control plan, the major water quality problem will occur in the leaching of a few feet of the edges of the pile during application of irrigation water or during natural precipitation or snowmelt periods. A dam will be constructed at a point on the lower end of the Sorghum Gulch watershed to collect contaminants, leachate or silt washed off the disposal pile. At this location all runoff from the disposal pile and any overflow runoff from the process area will be collected behind the dam, providing not only protection from contaminants from the pile but also providing backup protection to the process area. The dam or impoundment will be sufficient to withstand the 100-year flood. The procedure for determining this design flood is delineated in the U.S. Bureau of Reclamation book "Design of Small Dams", 1973 edition. The water collected behind the dam will be pumped to the processing area for use in the processed-shale moisturizer, again maximizing utilization of all possible contaminated water and minimizing use of higher-quality surface water.

Sorghum Gulch is estimated to have an average annual runoff volume of less than 100 acre-feet. If this runoff were permitted to accumulate behind the dam, the concentrating effect of evaporation would produce increasingly higher levels of salinity in the impoundment. The Lessee plans to use this water in the plant and in processed-shale disposal operations to reduce the overall water requirements of the plant complex wherever fresh water is not needed. Based on present estimates of the rates of water consumption for the plant and processed-shale embankment of about 9000 acre-feet annually, the entire annual runoff from the gulch would satisfy about 1% of plant water requirements, or a little more than 4 days. The majority of the runoff water drawn from the impoundment will be used to moisturize the processed shale. Because of capillary characteristics of the compacted shale, this water (together with whatever salts it contained prior to its use in the wetting process) is expected to remain in the embankment and is not likely to reenter surface or subsurface water systems. As a result, the concentrating effect produced by evaporation from the impoundment is expected to be minimal.

In order to protect the processed-shale disposal area from flash floods, the Lessee plans to build a series of temporary dams in the upper part of Sorghum Gulch, upstream from the processed-shale pile. A permanent dam will be constructed in the upper part of Sorghum Gulch to prevent long term erosion of the revegetated processed-shale pile.

e. Supporting Off-tract Facilities

Supporting off-tract facilities include roads, powerlines, product and by-product pipelines, waterlines and terminal facilities. After construction is complete, the potential for water quality degradation from these facilities is low.

In an effort to minimize any water quality problem from the Colorado River water pumping and transmission system, settleable solids removed from the water would be transported to a safe disposal area.

Terminal facilities near Rifle or Grand Valley would consist primarily of offices, a rail spur, loading docks and some tankage. Potentially contaminated waste water and sanitary sewage would be either treated and disposed of in leach fields, or would be pretreated as required and conveyed to local domestic treatment systems. All other facilities appear to have little potential for water quality degradation.

Noise Control

Noise Control

V. C. Noise Control Plan

1. Summary of Potential Noise Generating Activity

2. Lease Terms, Applicable Law and Regulations and Lessee's Plan for Noise Control

   a. Human Exposure Noise Limits
   b. Equipment Noise Level Regulations

C. Noise Control Plan

The development, construction and operation of the facilities on the Tract described in the DDP involves large equipment and machinery which will generate significant amounts of noise. The Lessee has developed this plan to identify the activities that will contribute significantly to noise occurrence, to identify the Lease terms and applicable law and regulation relating to noise control, and to define and describe Lessee's plans and procedures for noise control.

1. Summary of Potential Noise Generating Activity

During Phase I activity, noise generated on the Tract will occur primarily from mobile equipment, including trucks, tractors, construction equipment, generators, and drilling machinery used in connection with the construction of facilities. Additional noise will be generated by blasting and the construction and operation of development mining facilities, including lifts, ventilating fans and conveyors.

During Phase II, mobile equipment will continue to create noise during construction. During Phase III, the retorting and upgrading plant, and mining, crushing and conveying equipment will generate additional noise. Vehicular traffic bringing employees to the plant as well as other traffic involved in delivery of materials to and from the plant will add to the noise level.

2. Lease Terms, Applicable Law and Regulations and Lessee's Plan for Noise Control

Section 11 of the Lease, and Section 10 of the Stipulations, requires the Lessee to conduct all operations under this Lease in compliance with all applicable federal and state noise control statutes, regulations and standards. Section 10 of the Stipulations states: "The Lessee shall comply with all applicable Federal and State standards on noise pollution, as now in effect or as hereinafter amended, or, if they should be superseded, the standards superseding them. In the absence of specific noise pollution standards, the Lessee shall keep noise at or below levels safe and acceptable for humans, as determined by the Mining Supervisor."

The following federal and state noise control statutes, regulations and standards are applicable to portions of activities planned on the Tract (Table V-9).

Occupational noise exposure is primarily a health and safety concern, and excess exposure to noise can induce hearing loss in industrial workers. The Lessee plans to protect employees by compliance with the noise standards listed in Table V-9 and as discussed in the following

Table V–9 NOISE POLLUTION CONTROL STANDARDS

Government Agency	Applicable Noise Pollution Standard
Federal	
Environmental Protection Agency (EPA)	40 CFR Part 202 – Motor Carriers Engaged in Interstate Commerce Effective October 15, 1975
U.S. Mine Enforcement Safety Administration (MESA)	30 CFR Part 57 – Health and Safety Standards, Metal and Non metallic Underground mines
Occupational Safety and Health Administration (OSHA)	29 CFR Part 1910 – Occupational Safety and Health Standards
OSHA	29 CFR Part 1926 – Occupational Safety and Health Regulations for Construction
State	
Colorado	Colorado Revised Statutes, 1973, § 25 – 12 – 101 to § 25 – 108
Proposed Noise Standards	
EPA	40 CFR Part 205 – Transportation Equipment Noise Emission Controls

sections. Noise pollution regulations fall into two general categories: human exposure noise levels; and equipment noise level regulations designed to provide environmental noise levels safe and acceptable for humans.

a. Human Exposure Noise Limits

The U. S. Mine Enforcement Safety Administration (MESA) and Occupational Safety and Health Administration (OSHA) regulations are directed specifically at providing environmental noise level limits that will protect the hearing of industrial workers. Based on noise measurements made during prototype mining operations at the Colony Development Operation at Parachute Creek, it is anticipated that a planned program of noise control and hearing conservation will be necessary for both development and commercial mining. Noise levels within the mine and plant should be within the limits established by MESA and OSHA. In some cases, additional personal protection in the form of ear plugs, ear muffs and sound-proofed equipment cabs for some vehicles may be necessary. A noise control program which will include continuing noise exposure evaluation and regular audiometric examinations will be administered as a part of the complete noise control program.

The standard for occupational noise exposure promulgated by OSHA and MESA provides that protection against exposure shall be made whenever noise exceeds the levels listed in Table V-10 below.

TABLE V-10 OCCUPATIONAL NOISE EXPOSURE LIMITS

Duration Per Day (Hours)	Sound Level - dBA
8	90*
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

*Note: This standard is presently being examined for possible revision downward to 85 dBA.

The standard further states that feasible administrative or engineering controls are to be utilized to reduce exposure to noise. In addition, an effective hearing conservation program must be administered whenever sound levels exceed those shown in Table V-10.

The noise standards contained in 30 CFR Part 57 are identical to those shown in Table V-10. These regulations require that when feasible administrative or engineering controls fail to reduce exposure to within permissible levels, personal protection equipment is to be provided and used to reduce exposure to within the levels of the regulations.

Previous experience with prototype mine and crushing operations has shown that sound level measurements in working areas depend on the location and specific operation being conducted. In the mining operation, roof bolting on the upper level produced noise levels in the range of 74 to 117 dBA. However, hydraulic roof bolt drills are now available which reduce these noise levels by 10-20 dBA. Primary crushing operations produced sound pressure levels which ranged from 72 to 111 dBA, depending again on the location and specific operation being conducted during the test. These noise measurements indicate that noise exposure in the mine and crushing plant may need careful evaluation and corrective action.

It is important to note that the noise standards shown in Table V-10 are based on employee exposure to noise and not simply based on whether or not noise exists. Evaluation of relative noise hazards depends upon the degree of exposure to noise. In the design and operation of the commercial plant every effort will be made to apply administrative and engineering controls to minimize the generation of high sound pressure levels. Wherever feasible, equipment which produces low sound levels will be purchased and incorporated into the plant design. In the event it is necessary to utilize equipment which generates excessive noise, administrative controls will be applied to restrict the length of time employees will be exposed to the noise. In those areas where noise levels may exceed stationary levels, personal equipment such as ear muffs and plugs will be used. In addition, an effective hearing conservation program will be continually administered. This program will consist of continued monitoring of noise exposure, regular audiometric examinations of employees to measure the effects of noise exposure, and the proposed use of various types of noise control equipment. A noise monitoring program is presented in Section VI. G.

Where possible, the noise levels generated by development and commercial mine equipment will be reduced to below 90 dBA where equipment operators normally are positioned. This would eliminate the need for individual operators to wear protective hearing devices. This reduction will be obtained by use of sound-insulated cabs, engine mufflers, etc. Crushing-plant operators will be housed in a soundproof operating room equipped with closed-circuit television to monitor the crushing operation.

b. Equipment Noise Level Regulations

To keep environmental noise at or below levels which are safe for humans, the EPA and the State of Colorado have promulgated regulations which set noise standards for motor vehicles. Colorado standards also establish maximum permissible noise levels for certain other activities. Table V-11 lists the Colorado statutory noise limits.

Table V-11 COLORADO MAXIMUM PERMISSIBLE NOISE LEVELS

Zone	Day 7:00 a.m. to Next 7:00 p.m.	Night 7:00 p.m. to Next 7:00 a.m.
Residential	55 dBA	50 dBA
Commercial	60 dBA	55 dBA
Light Industrial	70 dBA	65 dBA
Industrial	80 dBA	75 dBA

Construction projects are subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed, pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project. Noises radiating from a property line at a distance of twenty-five feet or more in excess of the limits shown above in Table V-11 during the specified time period constitute prima facie evidence that such noise is a public nuisance. It is not anticipated that the activities planned for the Tract would generate noise levels approaching those listed for either light industrial or industrial zones at the Tract boundaries. However, the noise levels at the Tract boundaries will be periodically monitored during construction and operation activities to insure that these standards are met. If the noise level from the Tract activities exceeds the Colorado standard, the noise source will be located and the appropriate corrective action will be taken.

The EPA regulation (40 CFR Part 202), "Motor Carriers Engaged in Interstate Commerce", which became effective October 15, 1975, establishes the sound level limits as listed in Table V-12 for all motor carriers engaged in interstate commerce.

Table V-12 NOISE STANDARDS FOR MOTOR CARRIERS ENGAGED IN INTERSTATE COMMERCE

Speed Limit (MPH)	Sound Level (dBA)
35 or less	86
More than 35	90

*Sound level measured on an open site with fast-meter response at 50 feet from centerline of lane of travel.

All motor carriers engaged in interstate commerce for this project will meet these requirements by: 1) being equipped with exhaust systems which are free from defects which affect sound reduction; 2) being equipped with a muffler or other noise dissipative device; 3) not being equipped with any muffler cut-out, bypass, or similar device; and 4) being equipped with tires whose tread patterns are vented by grooves to the tire shoulder or circumferentially to each other around the tire. Motor carriers which meet sound level limits shown in Table V-12 are not subject to the tire requirement. Motor carriers will be properly maintained to insure meeting these EPA standards.

Historic and Scientific Values

V. D. Protection of Objects of Historic or Scientific Interest and Aesthetic Values

1. Objects of Historic or Scientific Interest

   a. Proposed Activity Affecting Objects of Interest
   b. Lease Requirements and Compliance Plan

2. Aesthetic Values

   a. Proposed Activity Affecting Aesthetic Values
   b. Lease Requirements and Compliance Plan

D. Protection of Objects of Historic or Scientific Interest and Aesthetic Values

The proposed development will result in surface modifications which could potentially destroy objects of historic or scientific interest. Likewise, development activities will affect certain of the scenic values and aesthetics of the area. As an initial part of the Lessee's plans to protect these assets, archaeological and scenic values studies have been undertaken on the Tract and surrounding area (Section XIII, Scenic and Archaeological Values). Additional efforts by the Lessee to comply with the Lease terms and other applicable regulations are described below.

1. Objects of Historic or Scientific Interest

a. Proposed Activity Affecting Objects of Interest

Past and future activities by the Lessee will result in the modification of approximately 155 to 220 acres of the landscape during Phase I and a total of 1555 to 2030 acres by the completion of the project, of which 1000 to 1200 acres will be the processed-shale pile. Proper precautions will be taken in advance of and during these developments to avoid damage to objects of scientific or historic interest. All areas that were not examined in detail under previous archaeological surveys will be evaluated prior to any site disturbance.

b. Lease Requirements and Compliance Plan

Section 6 of the Stipulations requires that Lessee not harm any object of antiquity or of historic or scientific interest. As part of the first year of baseline data-gathering programs, Tract-wide archaeological studies were undertaken by the Lessee. To date, all earth disturbances on the Tract have been preceded by a survey and investigation by professional archaeologists. This information can be found in Section XIII. The limited finds discovered at various sites during the studies have been marked and catalogued for preservation and future reference and will be considered during planning.

The OSEAP has recommended guidelines for protection of historic and scientific sites of interest. It is the intent of the Lessee to follow these guidelines and conscientiously investigate, record and protect any sites or materials deemed important or vital by professional investigators. The following procedures will be taken to assure that items of historic and scientific interest will be preserved:

> Qualified professionals will be used to evaluate, salvage and guide programs for historical, archaeological and scientific site protection prior to site disturbance.

- Qualified professional personnel will evaluate finds during earth moving operations; if earth moving reveals an object on the site, work will be halted until experts can evaluate the find.

- Notice of any discovery will immediately be given to the AOSS.

2. Aesthetic Values

a. Proposed Activity Affecting Aesthetic Values

As part of an overall plan to preserve the aesthetics of the area, a scenic value study of the Tract and vicinity was undertaken by the Lessee. The objectives of this investigation were: 1) to inventory the type and quality of presently existing scenic resources; 2) to determine the visual sensitivity levels (classes) of various parts of the Tract and surrounding area; and 3) to establish criteria for judging the effects of development on scenic values. A summary of the study is in Section XIII.

As a result of this study, it has been determined that few of the Phase I activities will be visible in most general views of the area. Local traffic on Piceance Creek road will see little of the construction activities since most of the Tract is not visible from this location. However, views from the Tract proper will be significantly altered as mine surface facilities, equipment and roads place new and locally dominant structural features onto the landscape.

During Phase II and Phase III activities, the plant structures and processed-shale disposal areas will not be visible in most general views of the area. However, these added facilities will be seen on clear days from ridgetop vantage points on the Roan Plateau. Steam plumes and temporary plant emissions during upset periods will vary in visibility as wind, air temperature and operating conditions vary. Plant facilities, rights of way, dams and reservoirs will be locally evident from vantage points on the Tract.

Phase IV activities will result in scenic values being restored to substantially their original condition.

b. Lease Requirements and Compliance Plan

Section 12 of the Stipulations requires Lessee to follow certain standards for the protection of scenic values and consider aesthetics in planning, construction, reclamation and mining operations. In general, the Lessee intends to incorporate the visual management guidelines developed by the U. S. Forest Service for retaining the scenic quality of the Tract and environment (Section XIII). The procedures set forth in Section 12 of the Stipulations also will be followed to minimize the impact on aesthetic and scenic values resulting from development activity. Specific procedures the Lessee intends to use in designing, clearing, earthmoving and construction are described below:

- Large volumes of materials will be placed so that the longitudinal axes are parallel to the existing ridge and creek patterns. Outlines will be shaped similar to the ridges of the surrounding area. Gentle undulations matching local draws and gullies will be copied insofar as possible. Straight lines of cuts and fills as well as other surfaces will be contoured and broken as much as possible so as to form loose, informal and natural-looking slopes. Irregularities of slope will be concentrated near the base of fills and tops of cuts with areas toward the roadway remaining geometrically more formal. This provides a gradual change from straight to natural lines and surfaces. Existing terrain features such as ridges, draws, gullies, etc., will be used as a guide to shape, mold, fill and cut slopes.

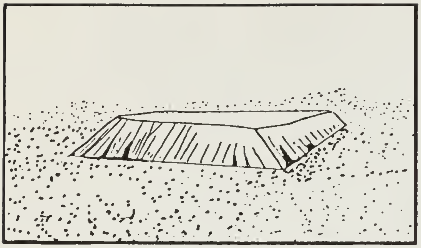
- Surface materials have a great influence on revegetation efforts and topsoil or seed bed requirements must take precedence over other considerations. However, where coarse material must be used to protect surfaces from rapid runoff, slopes will be built to resemble natural banding. If possible, surrounding natural irregularities will be repeated and matched, and embankment slopes blended into the surrounding natural terrain as shown in Figure V-13.

- New vegetation will be blended in by the proper combination of revegetation and geometric placement. Vegetative cover will be selected that is similar to surrounding native types.

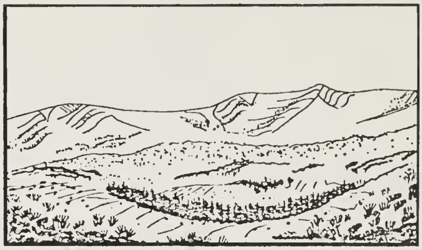
- Features will be designed to blend into a composite landscape design that is not only aesthetically pleasing, but preferable from an operations and maintenance viewpoint. Properly constructed and revegetated, even massive cuts as well as embankment slopes will become a part of the landscape.

- Slope rounding, which eliminates pronounced and artificial-looking edges of the cut and fill, will be done wherever possible. Sharp edges and uniform large surfaces will be avoided. Whenever possible, long uniform slope areas will be slightly undulated and warped to form side draws and small ridges as illustrated in Figure V-14.

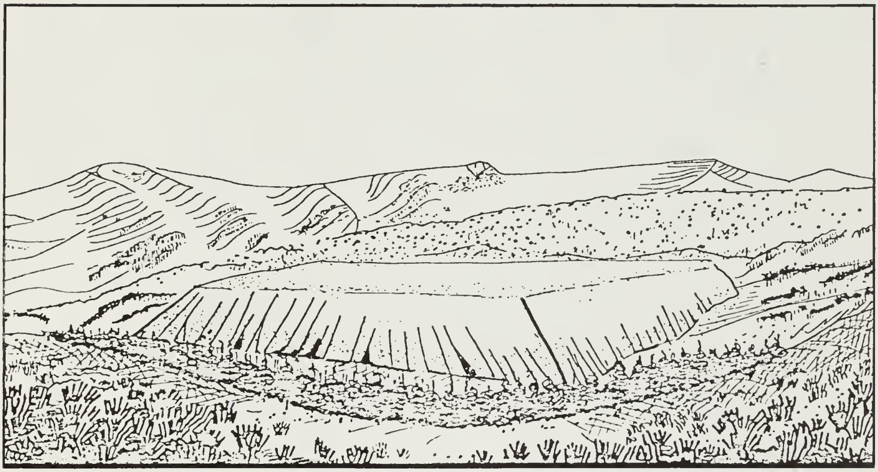
- For aesthetic reasons and also to minimize erosion damage (and where applicable to act as a noise barrier), efforts will be made to conserve valuable existing vegetation near or along the edge of the project facilities.



Processed Shale Pile



Landscape



Processed Shale in the Landscape

Figure V—13 LANDSCAPE BLENDING

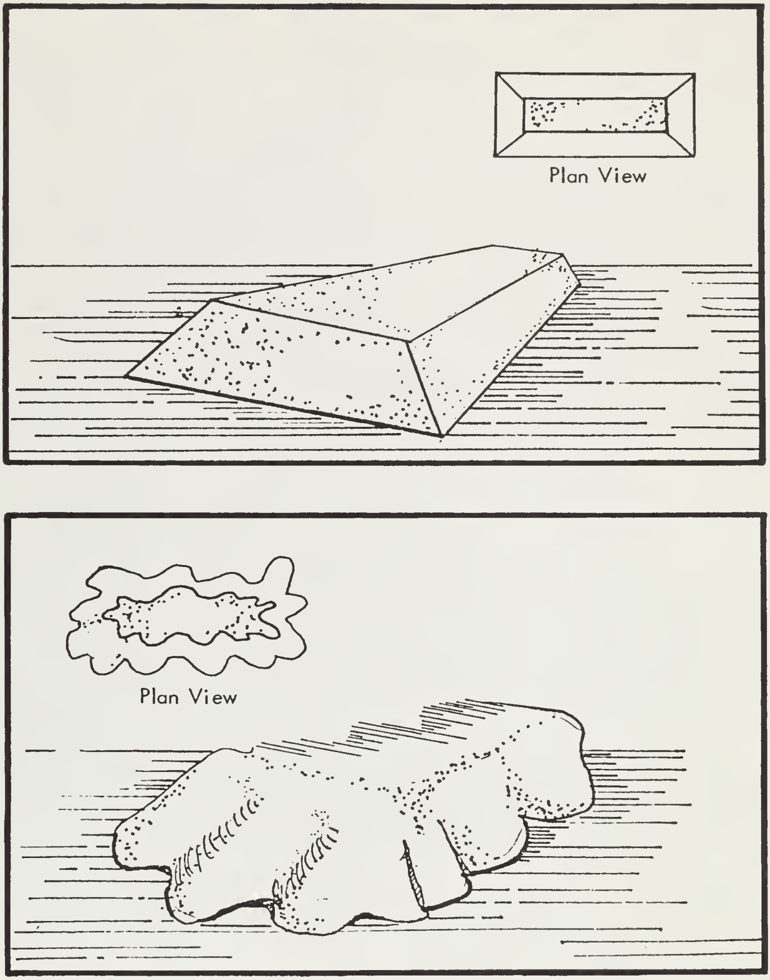
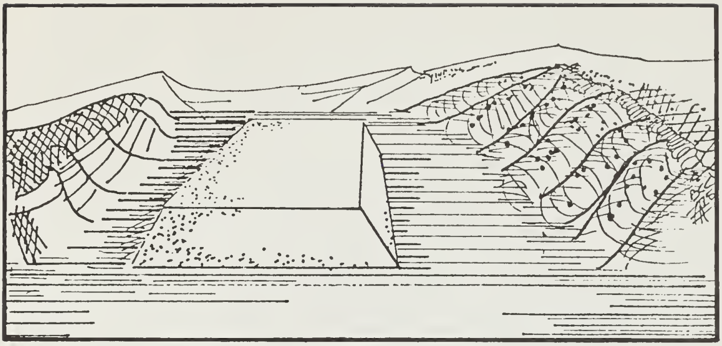


Figure V—14 VARIATION OF SLOPE ROUNDING



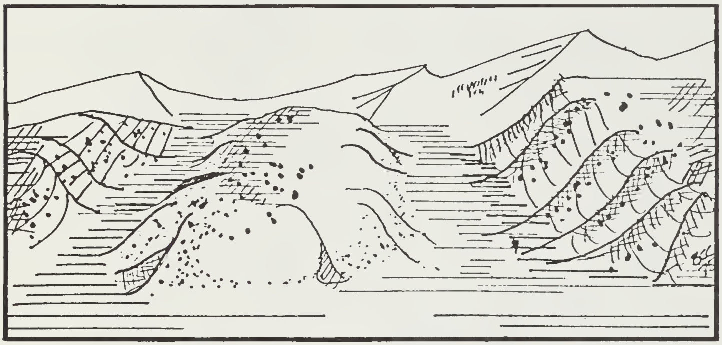


Figure V–14 VARIATION OF SLOPE ROUNDING
(continued)

- Future design work and actual construction surveying activities will reveal where, with some additional efforts, existing vegetation can be saved. Particularly in valley bottoms or along natural runs, slope rounding can be modified, and with some special placement of larger rocks, islands of trees or shrubs can be preserved.

- All structures will be colored, painted and textured to blend readily into their surroundings.

Fire Prevention and Control

Fire Prevention and Control

V. E. Fire Prevention and Control

1. Summary of Activities Which Have a Potential for Causing Accidental Fires

2. Lease Terms, Applicable Law and Regulations and Lessee's Fire Prevention and Control Plan

   a. Construction

      (1) Explosives and Blasting
      (2) Welding
      (3) Spark Arresters
      (4) Lunch and Warming Fires
      (5) Smoking
      (6) Gas Powered Equipment
      (7) Storage and Parking Areas
      (8) Burning Areas
      (9) Flammable Liquids

   b. Operations

      (1) Mine Operations
      (2) Plant Operations

E. Fire Prevention and Control

The possibility of accidental fire exists in connection with many activities to be carried out on the Tract. The Lessee has developed this plan to identify those activities which have the potential for causing accidental fires, to define the Lease terms as well as other applicable laws and regulations, and to describe Lessee's plans and procedures for preventing accidental fire.

1. Summary of Activities Which Have a Potential for Causing Accidental Fires

During Phase I, there will be substantial clearing of brush and trees from areas where facilities are to be built. Some of this material may be burned for disposal. The use of explosives in mining and construction also has the potential for causing accidental fires. The use of equipment such as welders, chain saws and motors which generate heat during operation pose fire potential. Human activity, principally smoking, is also a common cause of accidental fire. During both construction and operation, quantities of flammable materials including hydrocarbon liquids and gases will be stored or located on the Tract. These activities all pose potential fire hazards. Raw shale storage piles also pose a potential for fire by spontaneous combustion.

2. Lease Terms, Applicable Laws and Regulations and Lessee's Fire Prevention and Control Plan

Section 3 and 8(c) of the Stipulations requires Lessee to comply with the AOSS' instructions concerning the use, suppression and prevention of fires, and to carry out operations in accordance with designated procedures and standards. The Occupational Safety and Health Act, the Federal Water Pollution Control Act and regulations thereunder, the National Fire Codes and other federal statutes provide requirements for fire prevention. In addition, the Colorado Occupational Safety and Health Act and other provisions of state laws and regulations establish standards and regulations of activity for the purpose of preventing fires.

Reasonable design and proper operational safeguards can minimize both the potential for and the consequences of such hazards. During development and operation of the complex, clearing of brush and weeds from around facilities will be maintained and fire lines and clearings will be constructed when determined by the AOSS to be necessary for prevention of forest, brush and grass fires. Any uncontrolled fire will be reported immediately to the AOSS. Every reasonable effort will be made to prevent, control and suppress any fire on land subject to the Lease, and the Lessee will comply with the applicable instructions and directions from the AOSS.

a. Construction

Throughout all phases of construction, it will be the responsibility of the Lessee to see that all construction workers and supervisory staff, whether the Lessee's or his agents', are aware of fire control and evacuation procedures. All employees will be instructed to report any indication of fire to a central communication center immediately upon detection. No attempt to extinguish any fire will be made by an individual until assistance from other personnel has been requested.

The dispatcher, upon receiving report of the possibility of a fire and its location, will immediately notify the Lessee's on-tract fire control coordinator, who will dispatch appropriate fire-fighting equipment.

Emergency equipment will be stationed at a facility manned by assigned, trained personnel. The emergency vehicles will be equipped to fight fires from all sources and will be supported by additional trained personnel needed.

It will be the responsibility of the fire control coordinator to direct all fire-fighting activities on the Tract. His responsibilities will include assessing the size and character of the fire, determining the number of men required to extinguish the fire, directing crews for effective fire suppression and determining equipment and tools required. As deemed necessary, he may also request outside assistance from federal and state agencies in suppressing a fire.

At all times during the period of project development, a supply of fire-fighting tools or equipment will be furnished and maintained by the Lessee and located so as to be readily accessible. Project vehicles will be furnished with fire extinguishers and other control equipment. These tools will be clearly marked and reserved for use in fire control only. They will not be used in construction operations.
Fire boxes will be maintained and will contain sufficient tools to adequately equip the work crew during any given shift. Construction crews working on the project will be trained in fire control and be available to the fire control coordinator. Throughout construction on the Tract, every reasonable effort will be made to prevent fires.

(1) Explosives and Blasting

Only electric blasting caps and/or Primacord will be used as detonating devices in blasting activity. Explosives will be maintained at all times in a locked box plainly marked "Explosives." Electric blasting caps will be stored and kept in a separate locked heavy metal box at all times. During the dry season, a watchman will be on duty in surface areas for one hour after blasting to watch for fires in the area.

All federal, state and local laws concerning the use and storage of explosives will be complied with. The Lessee will furnish and erect special signs to warn the public of blasting operations. Such signs will be placed at appropriate points, maintained so as to be clearly evident to the public during all critical periods of blasting operations, and include a warning statement to have radio transmitters turned off.

(2) Welding

Welding will be accomplished in designated service areas when possible. If welding at field locations is required, the welding will be done at a location where all flammable material has been cleared away for a distance around the area. Adequate fire-fighting tools will be maintained at the site during welding.

(3) Spark Arresters

All diesel and gasoline engines, both mobile and stationary, will be equipped with approved serviceable spark arresters.

(4) Lunch and Warming Fires

The building of lunch and warming fires will be prohibited, or permitted only in designated areas where adequate fire-fighting tools will be maintained.

(5) Smoking

During the dry season, smoking will be permitted only in designated safe places or in areas where all flammable material has been cleared away. At no time will smoking be permitted in or near buildings containing gasoline, diesel fuel, oil or explosives, and such buildings will be posted with "No Smoking" signs. After plant construction, no smoking will be permitted in areas adjacent to plant facilities or tank farms.

(6) Gas Powered Equipment

All gasoline powered equipment will be required to have a muffler in good condition and operators will be equipped with chemical-pressurized fire extinguishers and round-point, long-handled shovels. Spill-proof metal safety cans will be used for refueling equipment.

(7) Storage and Parking Areas

The plant area, equipment service areas, parking areas, fuel storage areas and explosive-storage areas will be cleared of all flammable materials for a distance of 50 feet. Small stationary engine sites will be cleared of all flammable material for a distance of 15 feet. Flammable and explosive-storage areas will be labeled as such and "No Smoking" signs posted.

(8) Burning Areas

No burning will be done without the advance approval of the AOSS. If burning is permitted, certain precautionary steps will be taken to assure that the fire will not burn out of control.

The burning of any material will be done within a cleared area. Material will be piled into large, compact, dirt-free piles. A fire lane not less than twelve feet wide will be constructed completely around each pile under all conditions except when there is snow cover of four inches or more.

Based on the National Fire Danger Rating System, if Manning Class III or above is reached, all burning piles will be extinguished immediately. Follow-up checks will be made to be sure fires are dead.

A tractor equipped with a blade will be available during all burning to widen fire lanes and help stop advancing fires if necessary.

(9) Flammable Liquids

Construction activities will require the storage and use of fuels and flammable liquids in various areas of project work. Storage areas will be clearly marked and protected. Refueling operations will be confined to specified areas. Spills of flammable liquids will be controlled in the manner described in Section V. L., Oil and Hazardous Materials Spill Contingency Plan.

b. Operations

During the operational phase, trained crews and emergency equipment will be on a 24-hour standby at an established surface fire control facility on the surface. Because of the extensive time required to transport men and equipment down the mine shaft, a separate fire control facility will be established below ground.

(1) Mine Operations

Sources for underground fire include fuels and lubricants, equipment, explosives, mine supplies and trash.

Diesel fuel and lubricants employed in underground operations have low volatility and high flash points, making accidental ignition unlikely. Storage of fuels and lubricants underground will be limited to the minimum quantities necessary to maintain operations. Service and fueling operations will be conducted in specific areas and located near the mine exhaust air stream. Dry-break systems for fuel and lubricant transfers will minimize spill potential. Should a fuel fire occur underground, it would be extinguished with dry chemical extinguishers located on all equipment and, if necessary, with the mine fire truck, using high pressure fogging nozzles. The ventilation system in the development and commercial mine will be designed so that if a fire of any type should occur in any of the working areas, the area can be isolated and the smoke exhausted without affecting the remaining mine areas.

Mobile diesel equipment, conveyor belts and the electrical equipment associated with the mining activity also present potential sources of fire. Appropriate sensing and alarm systems and automatic dry chemical fire-suppression systems, in addition to the portable dry chemical extinguishers carried on all equipment, will be used for fire control.

The potential for explosives fires, though remote, is a possibility since ammonium nitrate-fuel oil (ANFO) explosive is flammable. Storage of explosives in compliance with federal and state regulations virtually precludes accidental fires in explosive storage areas. Only in a major mine fire involving the isolated explosives storage areas could a major explosives fire take place. Small quantities of explosives in transit to and from the storage areas or to the point of use are more susceptible to ignition by carelessness or by a fire in the transport vehicle. Proper control of quantities and procedures for transport of explosives will serve to minimize such hazards.

Flammable mine supplies include small amounts of lumber used in construction forms and packing containers for parts and supplies. Storage, use and disposal of these materials will be controlled. Trash from maintenance shops, warehouse and lunchroom areas will be disposed of in self-extinguishing collection containers established for this purpose. Waste will be periodically collected from these containers and transported to the surface for disposal.

Any indication of fire will be reported immediately via the central communications system to the fire control coordinator. No attempt will be made by any employee to control or extinguish any fire without first reporting the fire and seeking assistance.

The fire control coordinator, upon receiving report of a possible fire and its location, will dispatch appropriate fire-fighting equipment. Unless specifically determined to be unnecessary, he will activate the necessary audio, visual and olfactory systems to initiate evacuation of all except emergency personnel along prescribed and posted evacuation routes.

Emergency equipment will be stationed at a facility such as the maintenance shop or warehouse complex and manned by assigned, trained personnel. The emergency vehicles will be equipped to fight fires of all types and will be supported as necessary by the mine water trucks.

Preparedness training will be conducted regularly for all emergency crews. Fire control and evacuation procedure instructions will be given all mine personnel upon employment. Self-rescuer protection and instruction on evacuation procedures will be provided to all personnel and visitors to the mine area.

All emergency equipment and vehicles will be checked for preparedness by an assigned member of the emergency crew at the start of each operating shift, and all equipment will be returned to the state of preparedness immediately upon return from emergency dispatch.

The coordinator will be responsible for the initiation of the prescribed procedure for notification of management and appropriate local, federal and state officials in the event of an emergency. In the event of evacuation, the coordinator will remain at his post until all personnel have been accounted for or until relieved of responsibility.

Since oil shale contains a hydrocarbon material, it can be made to burn. Because of this, concern has been expressed that uncontrolled underground fires similar to those occurring in coal seams could occur. Experience to date indicates that such fires will not be a problem. A flame front can travel through a material only when sufficient permeability exists to allow movement of air and combustion gases through the formation. Oil shale permeability is very low, on the order of a few microdarcies, or about 10,000 times less than typical oil reservoir rock. Fractured areas may have permeability on the order of 10-100 millidarcies. However, volume expansion generally occurs during combustion and tends to seal off any permeability that may have existed because of fractures. Thus any fire involving in-place oil shale would be confined to its surface, spreading laterally only and at a very slow rate.

The primary forseeable effect of uncontrolled fire on subsurface geology would likely be thermal damage to pillars and the possibility of pillar failure followed by roof falls or subsidence. Such fire could only be caused by blasted rock in the mine. Due to the slow burning characteristics of oil shale and the planned wetting of muck piles after blasting, the possibility of uncontrolled fires appears to be very remote.

(2) Plant Operations

All of the hydrocarbon product streams in the shale oil processing complex are flammable and are handled at high temperatures. The problems and risks here are the same as for any petroleum refinery. An Oil and Hazardous Materials Spill Contingency Plan to minimize the risk of fires from oil spills is described in Section V. L.

Although a manned fire fighting facility under the direction of the fire control coordinator will be established for the surface facilities, it is also essential that all on-site personnel be properly instructed and trained in fire-fighting techniques. Adequate tools and equipment, readily accessible for immediate use in any emergency, will be maintained in accordance with good safety practices.

Turret nozzles will be located so that they can be quickly and effectively operated with minimum manpower. An adequate number of fire hydrants will be installed in locations that will allow the most efficient use during a fire or other emergency that requires large quantities of water.

Fire water sprays, hose reels, steam for smothering, heat-actuated devices, fire extinguishers, fire alarms and telephones will be installed as necessary for fire protection. Each operating area will be provided with proper and conveniently located emergency personnel protection equipment, such as fire blankets, canister gas masks, self-contained breathing equipment, safety showers and eye wash fountains.

All unit and equipment layouts, building designs and fire extinguishing systems, and the handling, transportation, storage, use and disposal of flammable materials will comply with all provisions of applicable National Fire Codes. If access to process units could be blocked during a fire, automatic fire-fighting equipment having remote shutdown will be installed in critical locations. Electrical conduit and air transmission lines that serve these remote devices will be fireproofed in areas where they could be damaged by fire. Also, automatic water deluge systems will be considered for pressure vessels in remote locations. Heat-actuated devices on the surface of the vessels will be used to detect any sudden temperature rise and open the remote deluge valve. A sloped berm will be provided around the vessels to drain away any hydrocarbon leakage and thus prevent flame envelopment. To minimize the possibility of liquid hydrocarbon overflow to adjacent areas, the diked volume will be designed in accordance with API standards and Lease requirements (see Section V. L.).

Fire and safety equipment for major pump manifold areas will be as complete as that for processing areas. Relief valves with vent lines that discharge a safe distance away will be installed on all headers that can be over-pressured. Turret nozzles and remotely controlled foam lines will also be considered for manifold areas.

Housekeeping and operating practices used will minimize non-process fire hazards. Fuel service points will be isolated from other structures and will utilize quick-connect equipment. This equipment also has automatic shut-off devices to limit spills. Posting of "No Smoking" signs will define potential fire hazard areas. A plant-wide alarm system will be used to alert all personnel to any emergency situations.

Although experience indicates that run-of-mine shale will not combust spontaneously, water will be used on stockpiles to control dust and safeguard against this phenomenon.

Health and Safety

V. F. Health and Safety

1. Summary of Potential Health and Safety Concerns

2. Lease Terms, Applicable Law and Regulations and Lessee's Health and Safety Plan

    a. Safety Program
    b. Medical Surveillance Program
    c. Possible Health Hazards
    d. Plant Safety Hazards

F. Health and Safety

The development of the Tract will involve the combined efforts of many people working in coordinated fashion. As in any industrial endeavor, human safety and health considerations must be given high priority. The Lessee has developed this plan to identify the activity and conditions which pose potential health and safety hazards; to review the applicable Lease terms, law and regulations; to set forth the Lessee's plan of compliance; and to provide a safe and healthful working environment. In addition to the plans set forth here, the Lessee has prepared other plans which are closely related to health and safety, but which are not repeated here. These plans include:

- Air Pollution Control (Section V. A.)
- Water Pollution Control (Section V. B.)
- Noise Control (Section V. C.)
- Fire Prevention and Control (Section V. E.)
- Disposal of Other Wastes (Section V. I.)
- Oil and Hazardous Materials Spill Contingency Plan (Section V. L.)

1. Summary of Potential Health and Safety Concerns

The potential for health and safety hazards exists during all phases of construction and operations.

During Phase I, the operation of a large variety of mechanical equipment and machinery, as well as the use of explosives for construction, shaft sinking and development mining, poses a constant possibility of accidents. Health and safety concerns also include noise and dust, which may affect hearing, respiration and sight. Mining, even with the most modern techniques, poses risks not encountered in most other industrial activity.

During Phase II and Phase III, construction activity and commercial plant operations involve potential health and safety risks similar to those of any modern refinery. Operating equipment, heat generating facilities, flammable substances and exposure to dust and chemicals used in processing all pose continuing risks. The control measures to be taken, most of which are conventional requirements for modern industrial facilities, are described below.

2. Lease Terms, Applicable Law and Regulations and Lessee's Health and Safety Plan

Section 5 of the Stipulations requires that Lessee take all measures necessary to protect health and safety and, specifically, comply with the Federal Metal and Non-Metallic Mine Safety Act of 1966 (30 USC 721-740) and with the Occupational Health and Safety Act of 1970 and the standards established therein.

The following general health and safety procedures will be followed by the Lessee.

a. Safety Program

All complex industrial operations, including the mine and processing plant planned for the Tract, involve a variety of potential health and safety hazards for employees. Safety hazards may result in immediate injury, while health hazards may result in occupational disease or impairment of ability due to exposure over a long period of time. The management of the C-b Shale Oil Project intends to provide and maintain working conditions which are as free from recognized hazards as modern industrial practice can make them. Efforts will be made to prevent accidents and occupational disease. A comprehensive plant safety program will be implemented around the following points:

- All levels of management realize that a complete commitment to the safety of both employees and the public is of paramount importance.

- An executive safety committee consisting of members of plant management will meet regularly to make and enforce plant safety policy.

- Regular safety meetings of superintendents, department heads and other personnel will be held to review executive committee recommendations and departmental safety records.

- New employees will be acquainted with Lessee's policy for accident and fire prevention and the personal responsibility of each employee for the prevention of injuries on and off the job will be emphasized.

- Supervisors will continuously participate in safety and health-related training programs which emphasize their role as the key to a successful safety program; supervisors will also be responsible for explaining safety concepts applicable to the general functions and specific jobs for which each is responsible.

- Active participation of employees and supervisors in safety educational programs and meetings will be stressed.

- An adequate staff of safety personnel will be maintained at the plant complex.

- Safety personnel will monitor all processes, work methods and controls to develop procedures to minimize the potential for accidents caused by human error and equipment failures.

- A comprehensive medical surveillance program will be established to detect any unexpected occupational health effects due to working in the plant and mine.

In order to identify and minimize health and safety hazards, the plant complex will be designed and operated in compliance with the standards of the U. S. Department of Labor, the Occupational Safety and Health Administration (OSHA), Mine Enforcement Safety Administration (MESA) and appropriate state agencies. In addition to compliance with these standards, available technology will be used to insure that sound industrial hygiene practices are followed.

Despite the effectiveness of any health and safety program, hazards cannot be completely eliminated, even in the safest of industries. The purpose of this section is to enumerate possible health and safety hazards which can be foreseen and discuss proposed control measures.

b. Medical Surveillance Program

In the mine and plant complex, long-term exposure to dust, gases, vapors and noise are potential health hazards. Some of the hazards are well-known, have been thoroughly studied and evaluated, and are carefully controlled by various conventional procedures and regulated by government. Other possible hazards may be classified as only speculative in nature and will require long-term monitoring for early detection of adverse symptoms. A medical surveillance program will be enacted to detect any unforeseen health problems.

The surveillance program will start by obtaining a complete medical, surgical, accident and occupational history for each employee. Those employees with positive findings will not be assigned to work in areas where exposure could aggravate their existing condition. Each new employee will be given a general physical examination. This will be supplemented with various laboratory and x-ray tests which may include:

- urinalysis including microscopic examination
- complete blood count
- SMA-12 blood test series
- chest x-ray
- pulmonary function test
- audiometric examination

Periodic physical examinations will be performed covering the items as listed above.

c. Possible Health Hazards

Dust. Controlling exposure to dust is required in mining, conveying, crushing and disposal operations. Dust is generated by the drilling, loading, scaling, hauling and bolting phases of mine operation. Underground blasting produces additional quantities of dust, although most mine personnel will be out of the mine during blasting. Sufficient time will be allowed for the mine ventilation system to reduce dust to safe levels before personnel enter the blasting area. Dust will also be generated during oil shale crushing, conveying and storage activities.

The degree of hazard attributed to dust depends on the chemical characteristics of the dust. Free silica in the dust is a recognized hazard, resulting in occupational silicosis. Conflicting results have been obtained in analyses of oil shale dust for free crystalline (alpha-quartz) silica. While some results have indicated approximately 10% silica in oil shale, one analysis has found no free silica in dust particles in the respirable size range. Exposure to respirable dust containing free silica is regulated by an OSHA standard. At 10% silica, the present standard would allow approximately 1 mg/m^3 of dust in the respirable range and 3 mg/m^3 of total dust. A proposed change presently under consideration would cut this in half. The new standard recommended by the National Institute of Safety and Health (NIOSH) is a time-weighted average exposure limit of 50 micrograms of free silica per cubic meter of air. This is designed to protect health for a 10-hour work-day, 40-hour work-week, over a working lifetime. Other recommendations or requirements include: medical examinations; possible warning signs in silica areas; using engineering controls, respirators and work clothing; giving information to employees concerning hazards; and sampling and record-keeping.

Based on dust sampling and control studies conducted previously, it is anticipated that the present silica exposure standard could be met with current control methods and practices. If the new NIOSH value is adopted, more stringent control techniques will be required. The dust control methods commonly used in mining operations are mine ventilation, water suppression and enclosure of dust generating equipment. Air tight cabs on vehicles and equipment are another means of protecting employees from dust.

During crushing operations, operators will work in soundproof, pressurized rooms equipped with filtered ventilation air systems. Air quality on the crushing and screening floors will be sufficiently controlled so that the use of respirators will only be necessary during upsets or emergencies.

At the shale processing plant, dust will be controlled by local exhaust ventilation systems, water sprays and maintenance practices designed to minimize generation of dust resulting from leaks and spills.

In addition to dust control equipment, a complete respiratory control program will be initiated. This program will include training in the proper use and care of respiratory equipment. Special medical tests, such as pulmonary function tests and appropriate x-rays, will be regularly conducted to detect incipient stages of dust-related diseases. Ambient dust concentrations will be continuously monitored by air sampling devices at various fixed locations and by personal inspection. In this way, any unusually high dust concentrations should be detected quickly and correctly. Records of dust concentrations will be maintained.

Potentially hazardous dust concentrations may also be generated during the handling and transporting of processed shale. The same standards for occupational exposure to dust will be applied. The main dust control methods will be: water suppression, respiratory protection and enclosed pressurized cabs for equipment operators, if required.

In certain special instances a hazard due to arsenic-bearing dust might exist. Employee exposure could occur during removal of spent hydrotreater catalyst material. The equipment and procedures for this operation will be designed to reduce dust concentrations to levels below the Threshold Limit Value for arsenic compounds (0.5 mg/m^3). A proposed OSHA standard may modify this level.

Air sampling and analysis of arsenic compounds will be conducted frequently during hydrotreater waste-material handling operations. As an additional precaution, respiratory equipment will be provided and special medical testing will be conducted when appropriate.

Carcinogenic Risk Potential. Petroleum and related products have been studied for many years in order to determine their carcinogenic potential. The results of these studies are available in the published literature. Early work in Scotland documented the carcinogenic potential of Scottish shale oil. Since shale oil may contain polynuclear aromatic compounds, some of which are potentially carcinogenic, studies have been conducted to determine the carcinogenic potency of raw shale, shale oil and processed shale produced by the TOSCO II retorting process.

Potential carcinogenic risks may result from prolonged exposure to processed-shale dust and shale oil by skin contact, inhalation and ingestion. The hazard of exposure to shale oil would be similar to that experienced in typical petroleum refineries. Direct contact with shale oil and processed shale would not occur during normal operations. Unusual operating conditions such as maintenance and shutdown may result in worker exposures.

The carcinogenic risk from potential exposure can be determined by a combination of chemical and biological analyses. Chemical analysis has shown that processed shale contains small amounts of benzo(a)-pyrene (BaP). A comparison of its BaP content to that of other common materials is given in Table V-13.

Table V-13 BaP CONTENT OF PROCESSED SHALE AND COMMON MATERIALS

Material	BaP, ppb
Coconut oil	43.7
Peanut oil	1.9
Oysters (Norfold, Va.)	10 to 20
Forest soil	4 to 8
Farm field near Moscow	79
Oak leaves	300 max.
Processed shale (TOSCO II)	38

Reports in the media have indicated that processed shale is carcino-- genic A conclusion apparently based on the scientific fact that benzo(a)pyrene (BaP) can be detected at the parts-per-billion level in TOSCO II processed oil shale. Published scientific literature indicates that: 1) BaP is formed during all pyrolysis and combustion processes; 2) BaP can be metabolized by living organisms; and 3) BaP is a natural metabolic product of plants and micro-organisms.

BaP is found in many materials which are not usually considered carcinogenic. Examination of Table V-13 shows that the amount of BaP in processed oil shale is comparable to that of many common materials. The establishment of carcinogenic potency for any chemical or complex mixture requires extensive biological testing.

Chemical analyses of shale oil indicate that the BaP content is similar to that found in various petroleum fractions. Table V-14 gives a comparison of BaP content in those petroleum products.

Table V-14 BaP CONTENT OF PETROLEUM PRODUCTS

Petroleum Products	BaP, ppb
Libyan crude oil	1,320
Cracked residuum (API Sample 59)	50,000
Cracked sidestream (API Sample 2)	2,000
West Texas paraffin distillate	3,000
Asphalt	10,000 to 50,000
Raw shale oil (Colorado)	4,000
Hydrotreated shale oil (0.25% N)	800

The relative carcinogenic potency of a chemical or mixture of chemicals may be expressed in relation to a chemical which has a well-established carcinogenic potential. A standard reference compound commonly used is 3-methylcholanthrene. The relative carcinogenic potency of shale oil is expressed as P_{MC} units (potency relative to 3-methylcholanthrene).

Skin-painting experiments showed that the carcinogenic potency of raw shale oil was P_{MC} units 0.1, and that of the upgraded (hydrotreated) shale oil was less than 0.03.

As shown in Table V-15, raw shale oil with P_{MC} = 0.1 has a carcinogenic potency which is comparable to many petroleum products. This confirms the carcinogenic rating of "weak" and "mild" as reported in the literature for raw shale oil.

Table V-15 COMPARABLE CARCINOGENIC POTENCY OF COMPLEX MIXTURES

Oil Product	P_{MC}
Industrial fuel oil	0.17 ± .01
Naphthenic distillate	0.06 ± .01
Dewaxed paraffin distillate from crude	0.06 ± .01
Cracked sidestream	0.26 ± .04
Coke-oven coal tar	0.54
Whole shale oil	0.10 ± .01
Upgraded shale oil	0.03

Upgraded shale oil, which may be the final product from a shale oil processing plant, can be considered as having a very low carcinogenic potency. The upgrading treatment significantly reduces the carcinogenic potency of shale oil. Upgraded and raw shale oils were applied to mice twice a week for their lifetimes (average lifetime is 80 weeks). The raw oil produced tumors in 78% of the animals, and the upgraded oil produced tumors in 10% of the animals. The average time for tumor formation, in the animals developing tumors, was 30 ± 2 and 49 ± 18 weeks for raw and upgraded oils, respectively. When evaluating the relative carcinogenic potencies, one should note that the raw shale oil has a carcinogenic potency similar to that of many petroleum streams. The carcinogenic potency of the upgraded shale oil is less than typical petroleum refinery streams.

The only recent industrial study of possible carcinogenic effects of oil shale processing was carried out in Russia, where processing and product utilization have continued for over 25 years. Examination of the workers has shown that continuous exposure to shale oils may have caused folliculitis, contact dermatitis and other minor skin diseases. It was concluded that the handling of these oils caused a sensitization of the skin to allergy reactions. The formation of skin cancer was not observed in this study. The marked decrease in the occurrence of cancers between Russian and Scottish shale oil operations may be attributable to an awareness of the importance of personal and industrial hygiene.

There has been no information stated in the literature which describes the carcinogenic potential of processed shale. As noted earlier, the low concentration (38 ppb) of BaP in processed shale is similar to non-carcinogenic materials. However, a program of animal testing has been initiated to define the carcinogenic potency of processed shale. The testing includes skin painting and lung and total exposure. Skin painting is carried out by applying an organic, concentrated extract of processed shale to the skin of the test animals. Skin painting is the classical technique for determining the ability of a material to cause skin cancer. Experimental results to date have shown no unusual toxic effects during the preliminary acute exposure phase.

Lung exposure of test animals is carried out by intratracheal instillation. In this procedure, a measured amount of processed shale is injected directly into the lungs. Test animals exposed to large doses of processed shale exhibited no unusual toxic or adverse health effects.

Processed shale is used as bedding material in the total-exposure experiments. The animals are exposed to fresh beds of material for their entire lifetimes. The routes of contact are by skin, ingestion and inhalation. Autopsies have indicated that the test animals received large doses by all routes of entry.

Preliminary observations of the test animals after 48 weeks of such total exposure has not indicated any toxic effect or carcinogenic potency of the processed shale. This experiment will continue for the lifetime of the test animals.

Noise. Although noise is a matter related to health and safety, it is treated in a separate Noise Control Plan in Section V. C.

Explosives Handling and Storage. The principal storage of explosives and blasting materials employed in mining will be in surface magazines of approved design conforming to existing regulations and located in accordance with the current American Table of Distances for explosives storage. Delivery of explosives to surface storage will be by suppliers' trucks.

Storage within surface magazines will be arranged so as to facilitate a first-in, first-out inventory system. Complete and up-to-date inventories of all surface-stored explosives, including details of receipts and issuances, will be made.

Trailer mounted magazines of approved construction, distinctive color and appropriate markings will be employed in transfer of explosives to and from storage in the mine. Separate portable magazines for explosives and detonators will be loaded from the surface magazines, lowered into the mine by service cages on a routine schedule, and towed to designated magazine locations underground. Capacity of these magazines will be such that routine mining activities can be sustained on a reasonable supply schedule and a minimum storage quantity underground.

Access to trailer magazines will be restricted to authorized personnel directly in control of blasting operations. The amount of explosives and detonators carried on the vehicle employed in the charging operations will be limited to that required for one shift's activity, and explosives remaining on these vehicles at the end of shift will be returned to the magazine areas.

Mine Explosions. There are a number of possible sources for uncontrolled explosions in any mine. The two most significant are explosive gases and explosive dusts. No explosive gases have been encountered in pilot mining of oil shale at the Colony Development Operation mine at Parachute Creek. However, traces of methane, a potentially explosive gas, have been encountered in exploration bore holes on the Tract. Present indications are that this gas does not originate in the mining zone, but its presence on the Tract dictates careful evaluation of potential problems. Detailed evaluation of gas occurrence is taking place as part of the mine development studies. If gas does occur in the mine, the danger of a gas explosion can be minimized by effective ventilation and other safety precautions.

The other important potential source of an uncontrolled explosion is explosive dust. Oil shale dust generated by mining activities has not proven explosive in mining experience to date. The major constituents of oil shale are silicate and carbonate minerals, with the combustible organic materials making up a smaller percentage of the material. In addition, oil shale, especially richer more-combustible oil shale, is not easily reduced to dust size. Studies are currently underway to further evaluate oil shale dust explosibility. Because dust explosions in coal mines are almost always initiated by gas explosions, the likelihood of a dust explosion in a oil shale mine, even if the dust were explosive, would be very small unless explosive gas is found to be a problem.

Any concern over explosivity would have to relate to "shelf dust", or dust accumulated on surfaces within the mine, and not with airborne dust. The concentration of dust required to make an explosive mixture in air is far higher (several thousand times) than allowed by breathing-air standards. However, an explosion resulting from other causes can pick up and entrain the shelf dust, which can then continue to propagate the explosion. The much greater ratio of air volume to surface area in a shale mine, as contrasted to a typical coal mine, would also greatly reduce the possibility of forming an explosive mixture by entrainment of shelf dust.

In the event of a dust or gas explosion, the effects of the explosion should be limited to the mine itself. Due to the large openings and great quantities of ventilation air used in oil shale mining, area propagation of a gas explosion should be minor, limiting damage to a relatively small area. A dust explosion could travel farther, but the absence of large volumes of dust to carry the explosion would tend to limit the extent of this type of explosion. The wetting of haul roads and muckpiles would also tend to limit dust explosion propagation.

A third and equally unlikely source of an uncontrolled explosion is the accidential detonation of explosives. The subject of safe handling of explosives is addressed in the preceding section, but it should be noted that the primary explosive agent planned for use in the mine is ammonium nitrate-fuel oil (ANFO) which is very stable and difficult to detonate accidentally, making such an uncontrolled explosion very unlikely.

In summary, uncontrolled explosions are possible, but not likely. Any damage resulting from such explosions would probably be restricted to the immediate area of the explosion, with a small probability of affecting mine areas away from the explosion or the surface above the mine.

Roof Falls. Roof falls are not an uncommon occurrence in underground mining, especially in bedded sedimentary deposits where large roof areas are exposed. Falls usually occur at intersections where roof spans are greatest. Roof bolting and appropriate roof span design minimize the likelihood of falls but can never eliminate them completely. Falls can occur as a result of bolt failures, unexpected geologic variations, excessive blasting shock, pillar failures, or any number of other factors impossible to predict. Experience indicates that falls are generally triggered by blasting, which takes place when no one is in the immediate vicinity of the blast area. Experience in other mines indicates that falls are frequently predictable using roof convergence information.

The effect of roof falls on underground geology is minimal. Roof falls are localized phenomena, ranging in size from a few hundred to a few thousand square feet and typically extending from 5 to 20 feet into the mine roof. Thus, only a small portion of the formation is affected.

The greatest significance of roof falls is in their danger to personnel and equipment. Careful design and monitoring of roof behavior, especially during development mining activities, should provide an understanding of roof behavior which will enable safe operation. Equipment also will be designed to afford as much protection as possible to the machine operators.

Other Unexpected Occurrences. This discussion deals with unexpected events of lesser probability and lesser impact than those noted above. Possible occurrences which can be addressed are massive water inflows, massive pillar failures, and seismic events. Other possible occurrences cannot now be predicted but are taken into account in design safety factors and will be dealt with using sound engineering judgment when and if they occur.

Massive water inflows could occur as a result of intersecting a zone of structural weakness (fault or shear zone) which would offer a low resistance conduit for water inflow,; or it could result from large scale structural failure causing fracturing, which would result in a large increase in the effective vertical permeability of the material above the mine. In either case, the magnitude of the inflow will depend on the characteristics of the aquifers above the mine, and can be estimated using information from the mineability studies, and later from development mine information. The large areas opened up within the mine would serve as a reservoir to accommodate the inflow until steps could be taken to control the flow, seal off the inflow area, or increase water removal capabilities. Many mining operations have learned to handle sudden inflows of water much larger than anything that could be anticipated on the Tract.

Pillar failures could result from inadequate or erroneous design or from unexpected large-scale structural geologic variations. The mineability geotechnical study will evaluate tract-wide variations in rock properties, but large areas of weak material could still exist between bore holes. Detailed information concerning pillar strength obtained during development mine operation will contribute to good pillar design. A safety factor will be incorporated into final commercial mine pillar design to reduce the likelihood of failure. However, the possibility does exist that unexpected rock strength variations will be greater than allowed for by the safety factor. If a large number of pillars were to fail simultaneously a major roof fall would likely occur, with the potential for propagation upward possibly resulting in surface subsidence. Such a massive collapse could produce an air blast which could cause damage to equipment and be hazardous to personnel some distance from the failure location.

However, such an event would probably not occur without warning. The instrumentation for the mine rock mechanics program (Section II) should provide information which would indicate in advance that a problem exists. Observation of pillar appearance and rock noises would also provide warning of potential difficulties, which could be dealt with by mining around the troublesome area or increasing the pillar size in that area. If failure appeared imminent, the area would be evacuated and steps taken to minimize damage. After such a failure, the area could be isolated by leaving large barrier pillars around the troublesome area and mining the remaining rock in the vicinity, using larger pillars if necessary.

The area of the Tract is a zone of relatively little seismic activity (Uniform Building Code Zone 1). Hence, significant seismic events are not anticipated. However, evidence of faulting is found a few miles from the Tract, indicating that seismic activity has occurred in the past and that the possibility exists for future occurrences. In addition, nuclear gas-stimulation projects have been conducted in the area in the past and could take place in the future during the period of mine operation. Nuclear stimulation shots produce effects very similar to seismic events.

The effect of seismic activity on mining operations has not been well documented. However, underground and surface mining operations are routinely carried out in areas much more active seismically than the Tract. In fact, most metal mining is carried out in areas of great structural deformation and instability, since these are the areas in which metal ores are typically found.

Because an underground mine is within the rock mass which moves during a seismic event, there is typically little effect on the mine itself. No opportunity exists for the differential movements or resonance phenomena so destructive to surface structures to occur. Passage of seismic or blast shock waves through mine roof and pillars can dislodge loose material, and the possibility exists that the additional stress induced by the shock wave could induce failure in marginally stable areas. Design safety factors are intended to take this into account. Monitoring performed in the Colony pilot mine during the Rio Blanco nuclear gas-stimulation test indicates that existing fractures in mine pillars and roof may open and then re-close during passage of shock waves. This would indicate that a long-term nuclear stimulation program subjecting the mine structure to many such shocks could have long term detrimental effects. In summary, no serious mining problems are expected as a result of seismic activities, although major nuclear gas stimulation efforts could be detrimental to mine stability.

Mine surface facilities would also be susceptible to surface seismic effects. Most mine surface facilities will be of conventional design, and should react no differently to seismic occurrences than other similarly constructed buildings. Design of buildings to resist seismic damage is a well established procedure, and all surface facilities would be designed in accordance with the guidelines established for Uniform Building Code Zone 1.

If planned pillar failure is used in mining the Tract, the mining program will be conducted in a manner to protect the safety of employees. Caving would be planned to occur in areas where no personnel are present.

Illumination. Proper illumination is essential to the safe operation of the mine. Illumination standards are included in the Health and Safety Standards for Metal and Non-metallic Underground Mines. These standards provide that illumination must be sufficient to provide safe working conditions on all surface structures, paths, walkways, stairways, switch panels, loading and dumping sites, and working areas for surface operations. For underground operations, individual electric lamps must be carried by all persons under the ground. The number of foot-candles for a particular light source is usually dependent on the type of operation. Since light values range from 5 to 150 foot-candles, illumination measurements will be conducted and all persons entering the mine will be provided with appropriate lamps.

d. Plant Safety Hazards

Much of the equipment in the plant complex will utilize electric power. High voltage units represent the most serious hazards. Only qualified personnel equipped with proper equipment will work on electrical power circuits. A distinct set of rigidly enforced safety regulations will apply to all electrical work. These procedures will include a detailed equipment lock-out procedure.

Although most conveyor belts are rather simple machines which require very little human attention, accidents related to conveyor belt operations and maintenance are common, and efforts will be made to prevent them. The conveyors used throughout the operation will be equipped with instruments to detect potentially hazardous mechanical failures before they occur. Belts and drive machinery will be protected by shields and guards as necessary. Conveyor belt covers and enclosures will reduce the chance of employees accidentally contacting the moving surface. All service points will be situated on the same side of the equipment to eliminate having to climb over or under operating machinery. Walkways will be well lighted. Emergency stop switches will be installed on each conveyor so that it can be deactivated at any point along the entire length of the belt.

Maintenance shops will service all mobile equipment involved in the operation and will be designed in accordance with OSHA specifications. They will be well lighted and will have ample room so that congestion can be avoided during normal maintenance operations. Whenever possible, equipment will be steam cleaned prior to entering the shop. Exhaust ventilation systems will be provided. Special protection will be included in welding areas. Each shop will contain a first aid station.

Operating equipment will be properly maintained to prevent mechanical failures which might cause accidents. The equipment will be well lighted and contain back-up alarms as necessary. Safety inspections will be conducted and special attention given to items such as lights, brakes and tires which could cause accidents if they fail to operate properly. Areas will be well lighted by stationary light standards, and dust will be controlled on the working surfaces. The potential for traffic accidents will be minimized in several ways. Where possible, traffic will be controlled in one-way flow patterns where loaded vehicles travel separate routes from empty vehicles. Speed limits will be enforced, and the degree of roadway curvature will be held to a minimum. Since all mechanical equipment will be equipped with two-way radios, accidents will be reported immediately. Operators will be instructed in safety practices and first aid to assist any injured worker. Ambulance service will be provided from the main processing plant area and surface facility. The mine will have a diesel-powered ambulance for underground use.

A well-trained operator, familiar with mechanical aspects of his machine, is the best assurance against accidents. Equipment will be provided with heated and air-conditioned or filtered-air cabs where conditions necessitate such measures. Attempts will be made in equipment design to minimize noise and operator fatigue. Operator training courses will be provided prior to assignment of vehicles. Operators will be familiarized with the control, operation and emergency procedures which should be followed in critical situations. The traffic ways and work areas will be regularly patrolled by supervisory personnel to help reduce careless or negligent operation.

All high-temperature equipment in the retorting complex will be constructed and operated under strict safety guidelines. Lines which carry hot solids such as ceramic balls, raw shale and processed shale will be insulated and designed to confine accidental spills wherever feasible. Steam lines and hot oil and vapor lines and equipment will be insulated and clearly marked or color coded to identify the contents of the various lines in compliance with OSHA standards.

Disposal of processed shale is largely a mechanical operation involving conveyors, trucks and other mobile earth-handling equipment. This type of mechanical system creates potential safety hazards in many areas. Among these are accidents related to conveyors and shop equipment, operation of large equipment, and traffic accidents involving haulage equipment. Equipment design will stress safety and regular operator safety meetings will be held to instill safe working habits in the operators.

Overburden Disposal

Overburden Disposal

V. G. Overburden Management

1. Summary of Surface Modification Activities

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

   a. Overburden Properties
   b. Excavation Procedures
   c. Conservation of Topsoil
   d. Stockpiling
   e. Stabilization and Rehabilitation

G. Overburden Management

Large amounts of the land surface will be excavated or otherwise disturbed as the result of the Lessee's developments on the Tract. This plan summarizes the various earth-moving activities, reviews the applicable Lease terms for controlling these activities, and details the Lessee's plan to comply with the Lease terms and other applicable regulations. In addition to the plans described here, the Lessee has prepared other plans which discuss certain aspects of overburden management. These plans are:

- Air Pollution Control (Section V. A.)
- Water Pollution Control (Section V. B.)
- Protection of Objects of Historic or Scientific Interest and Aesthetic Values (Section V. D.)
- Erosion Control and Surface Rehabilitation, Including Demonstration of Technology for Revegetation of Disturbed Areas (Section V. K.)

1. Summary of Surface Modification Activities

During Phase I, it is anticipated that from 155 to 220 acres of land will be excavated. These surface modifications include 35 acres of leveling for the mine site facilities, 40 acres of benching for the coarse-ore stockpile, 50 acres of cutting and filling for the main access road, 50 acres for dams and reservoirs and 45 acres for miscellaneous facilities. The rock excavated from the mine shaft will be used to construct the Sorghum Gulch dam site or as fill material in other construction. Phase II and Phase III land surface modifications, totaling a maximum of 1810 acres, will be restricted primarily to the development of the approximately 200-acre plant site, the 1200-acre processed-shale disposal area and other miscellaneous activity.

In summary, as shown in Table V-16, approximately 1555 to 2030 acres of land surface will be modified over the life of the project. Details of the specific facilities resulting in land surface modifications are described in Sections II, III and IV.

2. Summary of Lease Requirements, Applicable Laws and Regulations and Lessee's Plan for Control and Compliance

Section 14 of the Stipulations requires that the Lessee backfill or reclaim excavated material and processed shale. In addition, Section 11 of the Stipulations outlines numerous requirements concerning the handling of overburden and restoration of disturbed land on the Tract. Requirements relating to grading and backfilling and land restoration

Table V–16 PROPOSED SURFACE DISTURBANCE BY YEAR

DDP APPROVAL

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11 to end of operation	Total by Activity
PHASE I												
Mine Surface Facilities		25-35										25-35
Coarse Ore Conveyor		5-10										5-10
Coarse Ore Stockpile (Initial)		35-40										35-40
Road Construction (New)												
-Primary Tract Access		40-50										40-50
-Dam Access		10-15										10-15
-Primary Coarse Ore Conveying/ Stockpiling		5-10										5-10
Dam Sites (Sorghum & Cottonwood Gulches)		15-25										15-25
Construction Water		5-10										5-10
Reservoir (Sorghum Gulch)		5-10	10-15									15-25
PHASE II												
Truck Maintenance Facility						10-15						10-15
Plant Site						150-200						150-200
Processed Shale Handling System							15-20					15-20
Power R-O-W						5-15						5-15
Pipeline Corridor R-O-W								10-20				10-20
Road Construction (New)												
-Ventilation Housing Access						15-20						15-20
-Secondary Coarse Ore Stockpile						2-5						2-5
-Water Catchment Dam							10-15					10-15
Auxiliary Bldgs.								25-30		3-5		28-35
Coarse Ore Stockpile (Temporary)								25 35	15-20			40-55
Dam Site (Scandard Gulch)**							25-40					25-40
Reservoir (Scandard Gulch)**								40-70	50-100			90-170
PHASE III												
Processed Shale Pile										*	1000-1200	1000-1200
TOTAL BY YEAR		145-205	10-15			182-255	50-75	100-155	65-120	3-5	1000-1200	1555-2030-

*Acreage disturbance by processed shale pile will commence in Year 10 and continue to end of operations resulting in 1000-1200 total acres.

**Dam and reservoir constructed only if additional mine dewatering storage is needed.

generally are also set forth in 43 CFR Part 23. This plan addresses the activities planned for the Tract which will result in removal and utilization of overburden and outlines procedures to carry out such activity in an acceptable manner in compliance with the Lease.

The various considerations involved in overburden management are discussed in the following sections on overburden properties, excavation procedures, conservation of topsoil, stockpiling and stabilization and restoration.

a. Overburden Properties

The physical and chemical characteristics of typical topsoil, excavated rock and mine shaft waste rock from the Tract are given in Sections II, III, VIII and XII.

b. Excavation Procedures

Prior to commencing major excavations, the areas to be filled or cut will be cleared and grubbed to remove all vegetation including breaking large roots. After the area is cleared and grubbed, the topsoil, including broken-up roots and vegetation, will be removed and stockpiled or placed on areas ready for revegetation. After the clearing and grubbing operations and stripping of the topsoil, the areas will be rough-graded. Based on preliminary geological and geotechnical information, it appears that most of the plant site surface can be ripped (broken up by ripper teeth on bulldozers). Ripped material will be loaded and transported to fill areas and spread in layers of a thickness designed to facilitate compaction. After the material is spread by motor graders, scrapers and/or bulldozers, it will then be compacted by a compactor to obtain the desired results. The embankment construction will continue until the area reaches the limits of rough grading. The final elevation of the embankment will be achieved by fine grading. Rough grading and fine grading will be done during both Phase I and Phase II.

c. Conservation of Topsoil

Topsoil will be removed from the processed-shale site, Sorghum Gulch reservoir and coarse-ore stockpile site prior to covering these areas following direction by the AOSS. Topsoil material will be stockpiled for later use in revegetation, the processed-shale pile and other disturbed areas. The procedures used in removing the topsoil from these areas will be similar to the excavation procedures. The removal of topsoil from these areas will take place concurrently with their development so as to minimize surface disturbance.

d. Stockpiling

To minimize erosion and reduce dust generation from any stockpiled material, the pile will be benched, watered and revegetated or covered until it can be used. Small silt retention structures will be placed as required downstream from the fill area to control any increased sedimentation due to erosion of the fill. See also the Erosion Control and Rehabilitation Plan (Section V. K.).

Excavation and embankment construction of the dams for the processed-shale pile, coarse-ore stockpile, access and service roads, mine surface facilities and the process plant site will be conducted concurrently whenever possible. This will optimize earthmoving by balancing cut-and-fill quantities on a project basis instead of an area basis. This procedure would minimize the temporary stockpiling of excavated material.

e. Stabilization and Rehabilitation

The procedures described in the various plans included in Section V. will be utilized throughout the overburden removal, storage and utilization activities to insure compliance with the environmental criteria and controls required by the Lease.

Processed Shale Disposal

Processed Shale Disposal

V. H. Processed-shale Disposal

1. Summary of Proposed Activities Affecting Processed-shale Disposal

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

    a. Processed-shale Properties
    b. Production Quantities
    c. Site Selection
    d. Disposal Procedures
    e. Water Diversion and Control
    f. Stabilization and Rehabilitation

H. Processed-shale Disposal

Substantial amounts of processed shale will be produced as part of the Lessee's retorting operation on the Tract. The Lessee has developed a Processed-shale Disposal Plan to describe the proposed activity, review the applicable Lease terms, laws and regulations, and set forth the Lessee's plan for compliance. In addition to the plan set forth here, the Lessee has prepared other plans which discuss special aspects of processed-shale disposal. These plans include:

- Air Pollution Control (Section V. A.)
- Water Pollution Control (Section V. B.)
- Protection of Objects of Historic or Scientific Interest and Aesthetic Values (Section V. D.)
- Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas (Section V. K.)

1. Summary of Proposed Activities Affecting Processed-shale Disposal

The disposal of processed shale will commence with the start-up of the retorting facility. Processed shale will be produced from the retort at a rate of about 54,000 tons per day (dry basis). Over the life of the project, the processed-shale disposal area will be enlarged continuously, and will eventually contain 370 million tons and cover 1000 to 1200 acres on the Tract. All processed shale will be spread, compacted and graded to stable contours consistent with the surrounding terrain and revegetated.

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

Section 11 of the Stipulations requires that the Lessee shall: backfill and/or reclaim excavated material and processed shale and compact it thoroughly; design slope faces of waste piles to insure slope stability; revegetate slope faces and other areas in accordance with the rehabilitation plan; and comply with numerous requirements for the restoration of disturbed land. Certain regulations relating to grading and land restoration are also set forth in 43 CFR, Part 23.

Geologic and analytical data indicate that retorting the oil shale in the Mahogany zone on the Tract will produce essentially the same type of processed shale as that produced and studied extensively by the

Colony Development Operation. The properties of the shale from the potential mining zones below the Mahogany zone have not been as thoroughly defined. Preliminary information indicates that the processed shale from the R-4 zone would not be substantially different in character. A detailed description of the geology of the Tract and the potential mining zones is given in Section IV. C. 1., and Section VIII.

The various considerations in processed-shale disposal are discussed in the following sections on: 1) processed-shale properties; 2) production quantities; 3) site selection; 4) disposal procedures; 5) water diversion and control; and 6) stabilization and rehabilitation.

a. Processed-shale Properties

Processed shale, the residue remaining after retorting, will vary in characteristics and amount, depending on the grade and mineralogy of the raw shale, as well as on the retorting process. For the TOSCO II retorting process, and for shale of the grade and character of the shale on the Tract, approximately 80% to 86% by weight of the raw oil shale rock extracted from the mine will be left as processed shale after the retorting process. After the retorting process, the particle-size distribution of the processed shale is approximately 95% finer than U.S. Standard No. 4 sieve (0.185 inches), approximately 40% finer than No. 200 sieve (0.003 inches), and approximately 30% finer than No. 325 sieve (0.0018 inches). A typical size distribution is shown in Table V-17. The retorting temperature used in the TOSCO II process (about 900°F) is not sufficient to significantly decompose the carbonate content of the basic rock mineral. The processed shale contains a residual organic carbon content of about 5 weight percent, which imparts a charcoal color to the material. The remaining constituents include various inorganic matter. Table V-18 sets forth a typical analysis of the major components, after ashing, of processed shale produced by the TOSCO II process. Table V-19 presents the trace elemental distribution in typical processed shale, as determined with a spark-source mass spectrometer.

Dry processed shale is a dusty material with a low angle of repose. When moisture is added, processed shale behaves as a fine-grained silty material, which has been classified as a low-plasticity silt according to the Unified Soil Classification System. It has a pH ranging from about 7.5 to 9.0 and a specific gravity averaging about 2.52. Individual processed-shale particles as viewed under an electron microscope are crystalline and angular with slight variation in size. Large particles appear to be many smaller particles agglomerated together. The material is slightly more alkaline than the local soils. Although the processed shale has essentially the same mineral content as most native soils, it possesses a lower specific gravity. This difference in specific gravity most likely results from pores in the processed shale and is a significant factor in compaction density. See Table XII-3 for a listing of the constituents in the native soil.

Table V–17 PROCESSED SHALE PARTICLE SIZE DISTRIBUTION

U.S. Standard Sieve Size	Cumulative % Retained	Cumulative % Passing
4	4.7	95.3
10	11.8	88.2
20	17.4	82.6
40	21.2	78.8
80	39.0	61.0
100	44.8	55.2
200	60.4	39.6
325	69.0	31.0

Table V–18 ANALYSIS OF THE MAJOR CONSTITUENTS IN TOSCO II PROCESSED SHALE

Na_20	8.68
K_20	3.28
Ca0	15.8
Mg0	5.31
Al_20_3	6.80
$Si0_2$	33.0
Fe_20_3	2.52
L.O.I. (after correction for C, H_2, N_2, S)	15.8
Mineral C	5.71
Organic C	4.49
N_2	0.35
H_2	0.44
S	0.76

Table V-19 TRACE ELEMENT DISTRIBUTION IN PROCESSED OIL SHALE

Element	Concentration (wt. ppm)	Element	Concentration (wt. ppm)	Element	Concentration (wt. ppm)
Li	850	Zr	9.3	Gd	0.40
Be	35	Nb	3.4	Tb	0.07
B	140	Mo	4.9	Dy	0.40
F	1,700	Ru	< 0.1	Ho	0.07
Cl	72	Rh	< 0.1	Er	0.27
Sc	2.4	Pd	< 0.1	Yb	0.25
Ti	570	Ag	< 0.01	Lu	< 0.1
V	29	Cd	0.14	Hf	< 0.1
Cr	49	In	standard	Ta	0.04
Mn	34	Sn	0.11	W	0.42
Co	39	Sb	0.39	Re	< 0.1
Ni	11	Te	< 0.1	Os	< 0.1
Cu	15	I	< 0.01	Ir	< 0.1
Zn	13	Cs	1.2	Pt	< 0.1
Ga	2.2	Ba	32	Au	< 0.1
Ge	0.40	La	1.4	Hg	< 0.1
As *	50 (0.11)	Ce	1.6	Tl	0.14
Se	0.08	Pr	0.25	Pb	10
Br	0.01	Nd	1.2	Bi	0.36
Rb	29	Sm	0.44	Th	0.77
Sr	69	Eu	0.12	U	0.99
Y	1.2				

* Quantity in ( ) is water soluble.

b. Production Quantities

The total amount of processed shale produced will vary as a function of the grade and total amount of oil shale mined. For the purpose of estimating the quantities of processed shale which might conceivably be produced by room-and-pillar mining methods, the upper limit of the estimated mining intervals and the mid-range values of extraction ratios given in Section IV. C. 1. have been used. These assumed mining intervals and extraction ratios are not meant to represent the optimum or final mine design parameters; these parameters cannot be determined until the development mining program (Section II. E.) is completed. However, using these assumptions, it has been estimated that a maximum of 370 million tons and 280 million tons of processed shale might be produced from the Mahogany and R-4 zones, respectively.

c. Site Selection

Locating and preparing processed-shale disposal areas includes many of the same considerations discussed in regard to overburden management (Section V. G.). As with overburden management, environmental factors and economic factors are the major considerations. Again, the factors tend to be mutually supportive. One obvious requirement is an area with sufficient volume to dispose of the total processed-shale output. Another is a site which will minimize flood control and drainage problems, lend itself to construction of a water quality control dam downstream, and allow grading to a stable pile configuration.

Several areas on the Tract, or at least partially on the Tract, would be suitable. These areas include Sorghum Gulch, West Fork Stewart Gulch and Scandard Gulch. Cottonwood Gulch is too small in capacity for consideration. Sorghum Gulch is the best location because of its large storage capacity and small upstream watershed. The storage capacities of the various gulches are given in Table V-20. A disposal location in Stewart Gulch, Willow Creek or Scandard Gulch would require extensive flood control facilities because of the large watersheds of these respective creeks or gulches upstream of the Tract.

Based upon a requirement that all disposal be on-tract, the on-tract portion of Sorghum Gulch is the best site from the standpoint of available volume and water diversion requirements. The portion of Sorghum Gulch which lies on the Tract will hold all the processed shale expected to be produced, although the pile will rise above the ridge lines. Also, by placing the pile completely on-tract in essentially the middle of the watershed, the upstream water must be retained in a catchment dam upstream of the pile. If the pile could be extended to the upstream watershed area south of the Tract, it would eliminate the need to form the pile higher than the surrounding terrain and minimize the need for water catchment dams. The off-tract disposal plan is not being considered due to uncertainty in federal land law and policies.

Table V–20 PROCESSED SHALE STORAGE CAPACITIES OF

VARIOUS GULCHES ON TRACT C-b

(Tons of Processed Shale at 90 pounds per cubic foot)

Elevation Feet	Sorghum Gulch	Cottonwood Gulch	Scandard Gulch	West Fork Stewart Gulch	Total
6,600	1,844,000	45,000	5,300,000	450,000	7,639,000
6,700	14,650,000	5,180,000	27,900,000	6,930,000	54,660,000
6,800	57,400,000	26,400,000	77,500,000	24,900,000	186,200,000
6,900	149,300,000	61,000,000	144,300,000	57,000,000	411,600,000
7,000	276,000,000	87,500,000	205,000,000	96,300,000	664,800,000
7,100	398,000,000	98,400,000	246,000,000	124,500,000	866,900,000
7,200	493,000,000	101,000,000	270,000,000	136,200,000	1,000,200,000
7,300	549,000,000		281,000,000		1,067,200,000
7,400	578,000,000		284,000,000		1,099,200,000

However, if these laws and policies are clarified in the future, the environmental and aesthetic advantages of using off-tract storage would require reconsideration.

Another very important factor in the location of the processed-shale pile is proximity to the plant. The Sorghum Gulch location is conducive to short conveyor runs, which reduce both costs and environmental effects. The economics of placing the pile in any other location appear to be unfavorable enough that very significant environmental or other reasons must exist before any other location should be considered.

d. Disposal Procedures

Moist processed shale emerges from the retorting operation at a temperature of about 200°F. The moisture content will be raised to about 14% on a dry-weight basis as it leaves the plant moisturizer. About 1% of this moisture will evaporate during transporting, spreading and compaction operations. The initial moisture content in the disposal pile will thus be about 13% by weight.

The processed shale will be placed on a belt conveyor for transport overland to the disposal site. To retard moisture loss and prevent fugitive dust from escaping during transport, the conveyor will be covered to prevent wind from disturbing the material. The processed shale will cool during transporting. The conveyor system will include one main conveyor and a standby conveyor for use in emergencies, as shown in Figure IV-2. The standby conveyor could also be used when the end of the first conveyor is relocated as the embankment rises in elevation.

The conveyor system will occupy a strip of land approximately 30 feet wide and will include an adjacent service road. Construction of the road and conveyor will require excavating for the road and building a ground support base for the conveyor. The service road will be used to maintain the conveyor and to remove any spillage which may occur. At the end of the conveyor, a surge bin and truck loading facility will transfer the material to either of two truck loading positions or to an emergency bypass stockpile if no trucks are available for loading. As the working surface rises in elevation, the off-loading facility will be periodically relocated upward to avoid uphill hauling to the working area.

The processed shale will be loaded directly from the conveyor at the off-loading facility into 150-ton bottom-dump trucks and transported to the working area. The material will be deposited on the surface of the embankment in layers approximately 18 inches deep, and then compacted. Fugitive dust from the hauling, dumping and spreading operations will be controlled by the use of a water truck equipped with a sprinkler system. The water truck will service the haulage ways and the active surface areas.

Placement of processed shale will require precise timing and control of the placement sequence. The relatively narrow valley bottoms and areas adjacent to exposed slopes provide limited working spaces. Placement activity cannot be entirely localized in such restricted areas, so it will be spread out to permit adequate equipment working space. Most of the processed shale will be placed in the interior portion of the fill area and compacted to a density of about 85 pounds per cubic foot. Processed shale placed in the frontal portion of the pile will be compacted to 90 pounds per cubic foot.

Usable soil and overburden materials will be removed ahead of filling and stockpiled for reuse in reclamation. This removal will be done as embankment height increases and will proceed concurrently with filling operations. Overburden materials will be removed and placed directly on completed surfaces to minimize stockpiling and multiple handling. Stockpiles will be built upstream of the fill if space permits, but not on the plateau or ridges (Section V. G., Overburden Management Plan).

The mine will be designed to support the additional load imposed by the processed-shale pile. Views of the processed shale-pile configuration at various stages of construction are shown in Figures V-15 thru V-19. One longitudinal and three transverse cross sections of the processed-shale pile, taken as indicated in Figure V-19, are shown in Figure V-20.

Backfilling the mine with processed shale is a potential method of reducing the amount of processed shale disposed of on the surface. However, according to present plans, at least initially the processed shale will be placed on the surface of the Tract. In order to dispose of all the processed shale underground, the mine would have to be filled completely and compacted to an average density of approximately 115 pounds per cubic foot. The attainment of compaction densities of this magnitude requires the use of very large and heavy mechanical compaction equipment. Because of the size of the equipment, it would not be possible to produce the required density in the upper portion of the mine cavity. Space will have to be provided between the top of the pile and the roof of the mine to permit movement of the equipment over the pile. Although the remaining void could be filled by slurry or pneumatic methods, this technology has not been tested and cannot be tested on an adequate scale until substantial portions of the mine can be used for such testing. It is also unlikely that any combination of these methods would produce average densities in excess of 90 to 100 pounds per cubic foot. As a result, some of the processed shale would have to be disposed of outside the mine.

In addition to compaction limitations, mine design and subsurface environmental considerations would delay the start of backfilling operations to a time when such operations would not interfere with normal mining functions. Backfilling could begin as soon as a large section of the mine can be isolated from active mining. Sufficient time

Figure V–15 PROCESSED SHALE PILE: YEAR 3

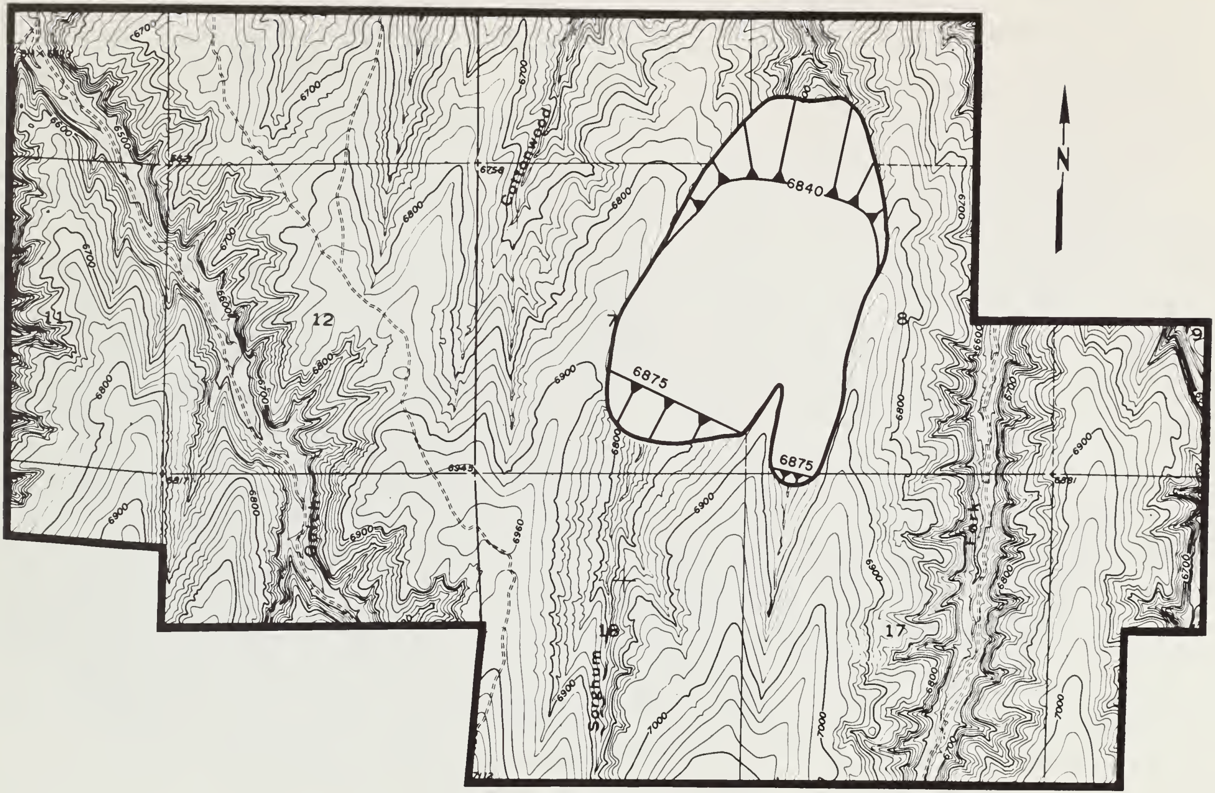


Figure V–16 PROCESSED SHALE PILE: YEAR 5

Figure V–17 PROCESSED SHALE PILE: YEAR 10

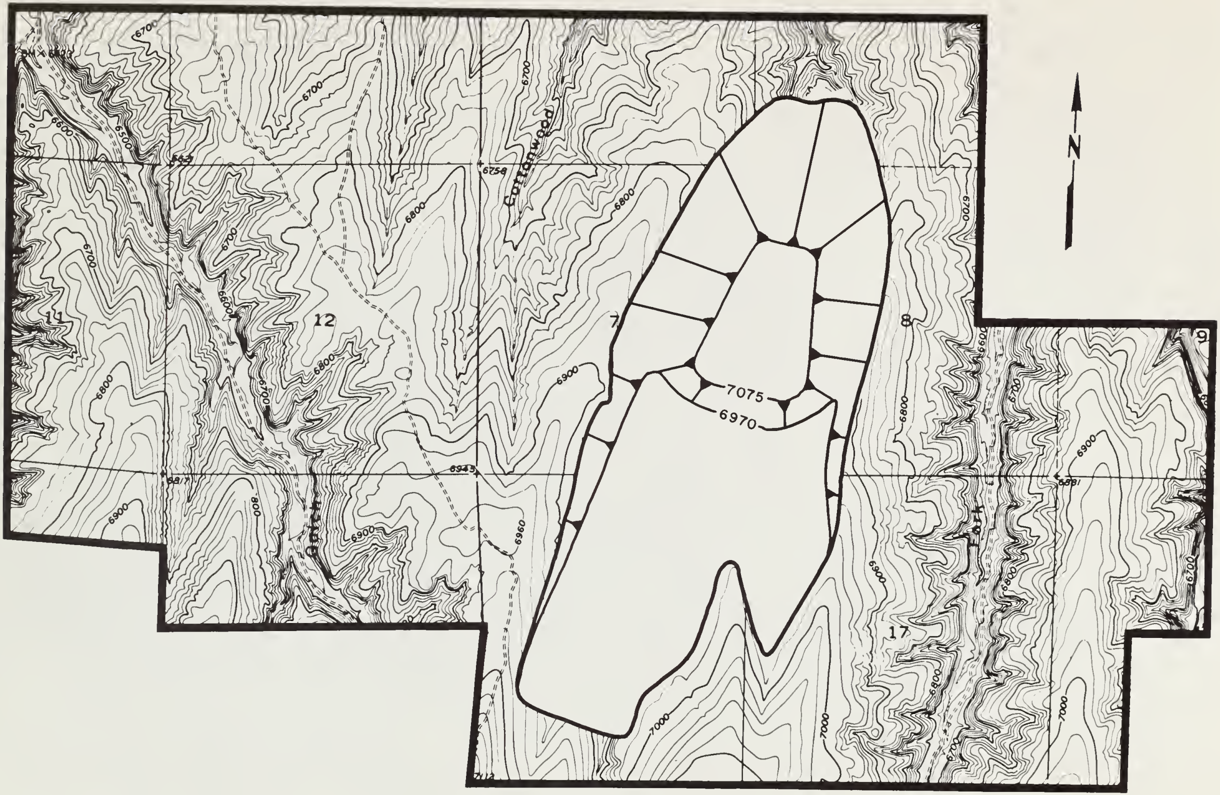


Figure V—18 PROCESSED SHALE PILE: YEAR 15

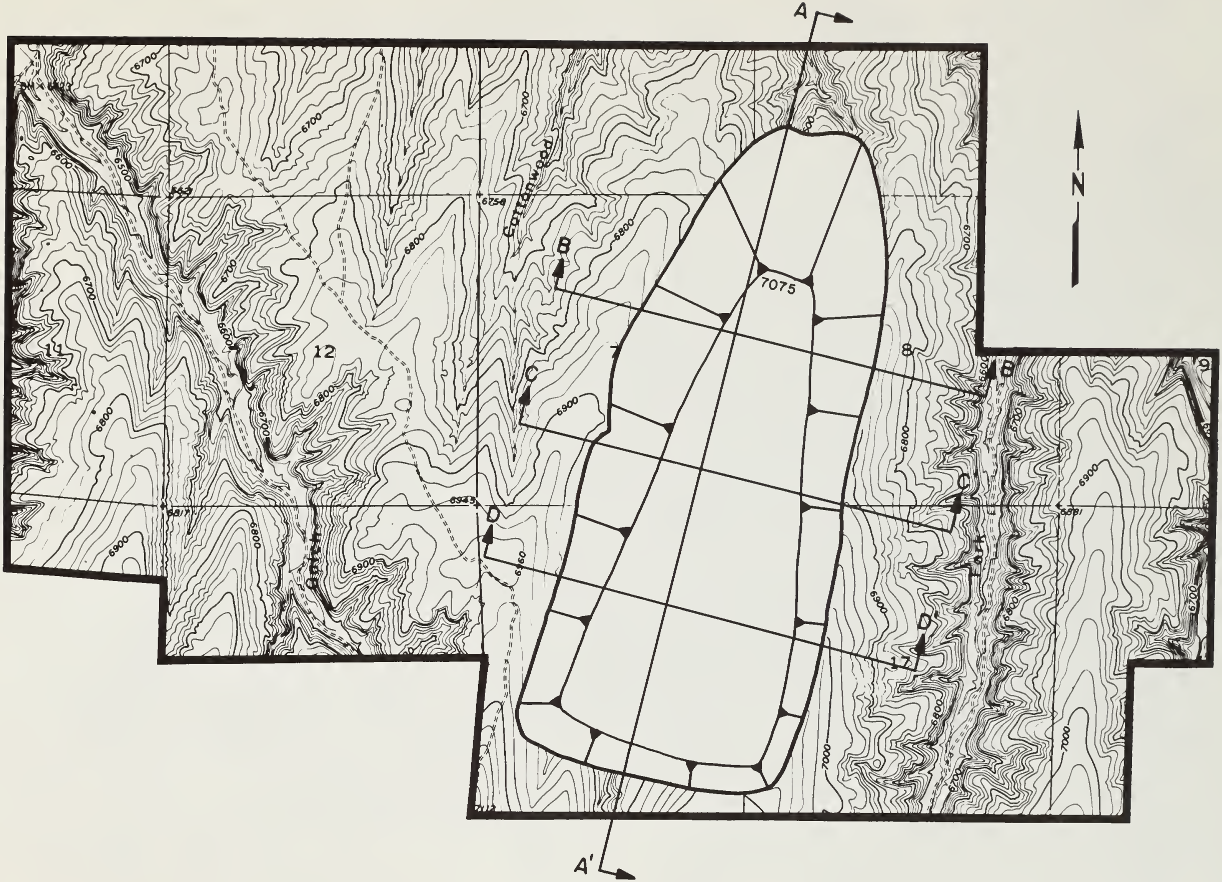


Figure V–19 PROCESSED SHALE PILE: YEAR 20

would also be required to completely develop the full mining interval in a large section of the mine, modify the ventilation system, and isolate the mined-out area. It is expected that such an area would be available within 5 to 10 years after the start of production.

Preliminary studies have indicated that prior to underground disposal, processed shale would have to be cooled substantially below the 200°F temperature at which the shale will leave the retorting facility. The temperature would have to be reduced to a level at which men and equipment could operate safely. This additional cooling would have significant economic impact. However, these studies also indicated that processed shale could be placed in the mine at temperatures up to approximately 200°F without creating a fire hazard or detrimental thermal effects on any overlying ground-water aquifers. Higher temperatures could greatly reduce the structural stability of the backfilled area through partial retorting, spalling, and expansion of the pillars, floor and roof. In addition to the mine structural considerations, the potential for ground-water contamination will require study.

A possible alternative would consist of combined surface and underground disposal. Processed shale from the initial years of operation would be disposed of on the surface; then the remaining production could be disposed of underground if experimental underground disposal proves feasible.

An additional study of alternate methods of placing backfill in the mined-out areas and the economics and impacts of these methods is currently under way. Completion of the study will provide further information on the benefits and economics available from backfill disposal and provide definition and direction for further consideration and planning. The study is evaluating alternative systems such as hydraulic, pneumatic and mechanical placement, the economics of each system and/or combined systems, and their possible effects on the mine structure and environment.

Processed-shale ash is the product obtained after burning the residual carbon from processed shale. Studies have been made to evaluate the potential commercial value of this ash. Their principal conclusion is that of the many possible uses of processed-shale ash that have been considered, all will require further research and testing to develop products. These studies have also shown that for an oil shale plant processing approximately 66,000 tons per day of raw shale, only a small fraction of the processed-shale ash could be commercially utilized. However, with increasing populations, particularly in Western Colorado, the depletion of natural building materials such as pumice and scoria for concrete block and natural shales for cement may open up a number of potential markets for processed-shale ash. It is possible that within four to five years after an oil shale industry starts approximately 500,000 tons per year of processed-shale ash could be consumed. The various potential uses and estimated annual consumption are as shown on Table V-21.

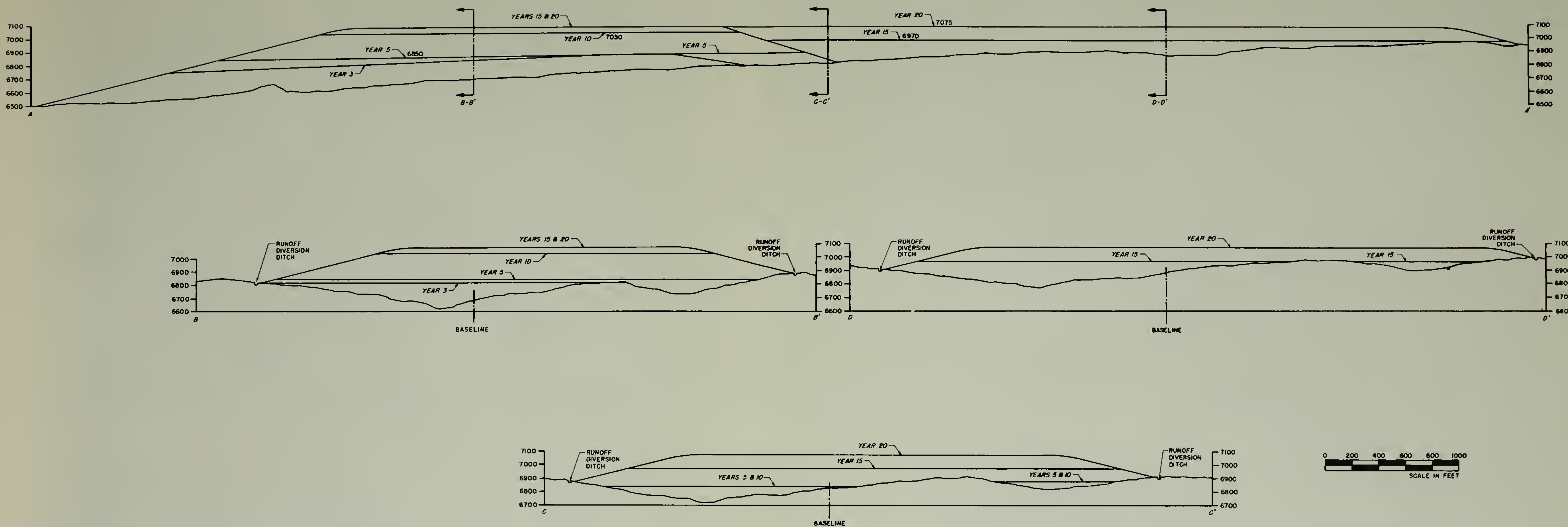


Figure V–20 PROCESSED SHALE PILE – LONGITUDINAL AND TRANSVERSE CROSS SECTIONS

Table V–21 POSSIBLE USES OF PROCESSED SHALE

USES	TONS/YR BY 1980
A. Asphaltic concrete	300
B. Mineral wool	0
C. Lightweight aggregate – highway use	10,000
D. Lightweight aggregate – structural concrete and concrete blocks	250,000
E. Rubber filler	1,000
F. Road Base and sub-base materials	40,000
G. Drilling mud	0
H. Oil well cements	0
I. Catalysts	0
J. Mineral fillers	0
K. Building brick	20,000
L. Portland cement	250,000
	571,300

The environmental effects of processed shale being turned into marketable items would stem from transportation modes and manufacturing processes. Most notable would be air emissions from the transportation vehicles and processing plants and air emissions from the increased processing required to convert the processed shale into usable commodities. These air emissions are not quantifiable at the present time.

As mentioned previously, the most desirable processed-shale disposal site on the Tract is Sorghum Gulch. It has been selected as the primary surface disposal area because of its close proximity and accessibility to the primary process plant site, its relatively large storage capacity within the Tract boundary, and its relatively small upstream watershed which minimizes the requirements for surface water diversion. Off-tract disposal may be economically and/or environmentally preferable, but is not a viable alternative without specific government approval.

In addition to the planned disposal sequence discussed above and depicted in Figures V-15 through 20, preliminary studies of four alternative disposal cases have been conducted. The four cases, described below, are based on the same assumptions discussed in Section V. H. 2. b.

Case I - Mahogany zone. Mining is limited to a 75-foot height in the Mahogany zone. A total of about 370 million tons of processed shale will be produced.

All processed shale can be stored in Sorghum Gulch below elevation 7080 feet within the Tract Boundaries, or extending off-tract below elevation 7030 feet (See Figure V-21).

Case II - Mahogany zone and R-4 zone. A 75-foot mining height in the Mahogany zone and a 55-foot mining height in the R-4 zone are included. A total of 650 million tons of processed shale will be produced.

The 650 million tons of processed shale produced can be stored on the Tract by using Sorghum Gulch to elevation 7400 feet (maximum) and Cottonwood Gulch to elevation 6900 feet. All processed shale can be stored in Sorghum Gulch below elevation 7180 feet by extending the embankment off-tract (Figure V-22).

Case III - Mahogany zone - Mine Backfilling. By backfilling, approximately one-half of the 370 million tons of processed shale produced in Case I could be stored underground, leaving 185 million tons for surface disposal. This amount can be stored in Sorghum Gulch, on the Tract, below elevation 6940 feet (Figure V-23). Surface disposal would be used for the first few years of operation until mining progresses far enough to provide room for backfilling.

Case IV - Mahogany zone and R-4 zone - Mine Backfilling. Approximately one-half of the 650 million tons of processed shale from Case II,

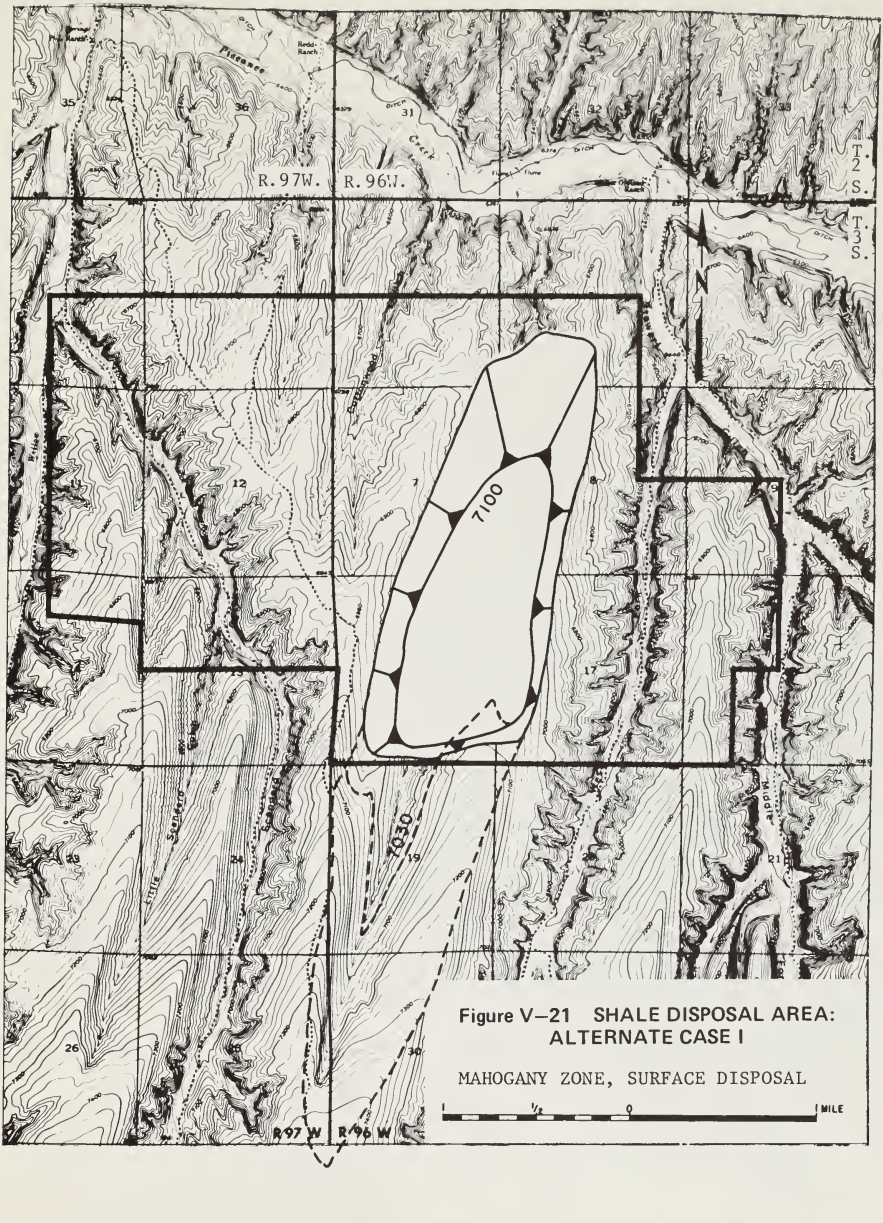


Figure V–21 SHALE DISPOSAL AREA: ALTERNATE CASE I

MAHOGANY ZONE, SURFACE DISPOSAL

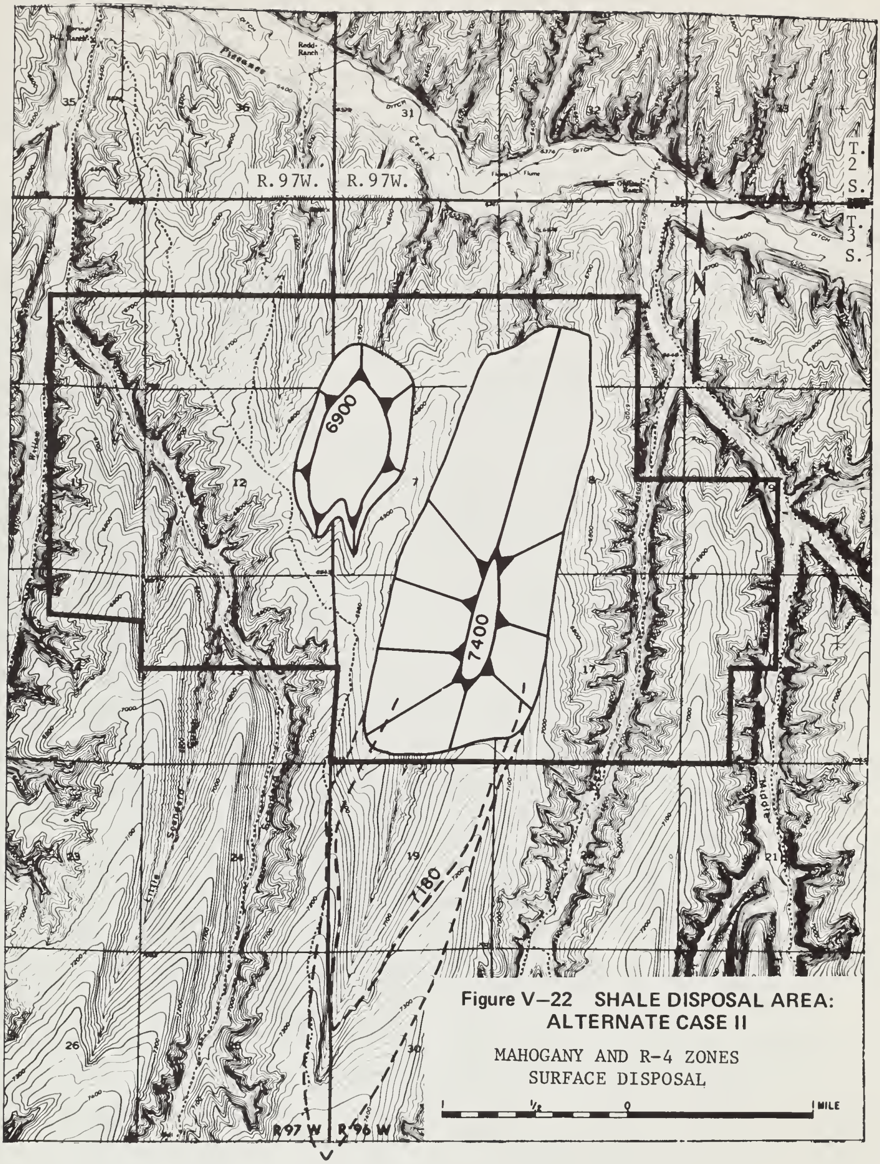


Figure V–22 SHALE DISPOSAL AREA: ALTERNATE CASE II
MAHOGANY AND R-4 ZONES
SURFACE DISPOSAL
1/2
0
1 MILE
R.97W.
R.97W.
T.2S.
T.3S.
6900
7400
7180
R97 W
R 96 W

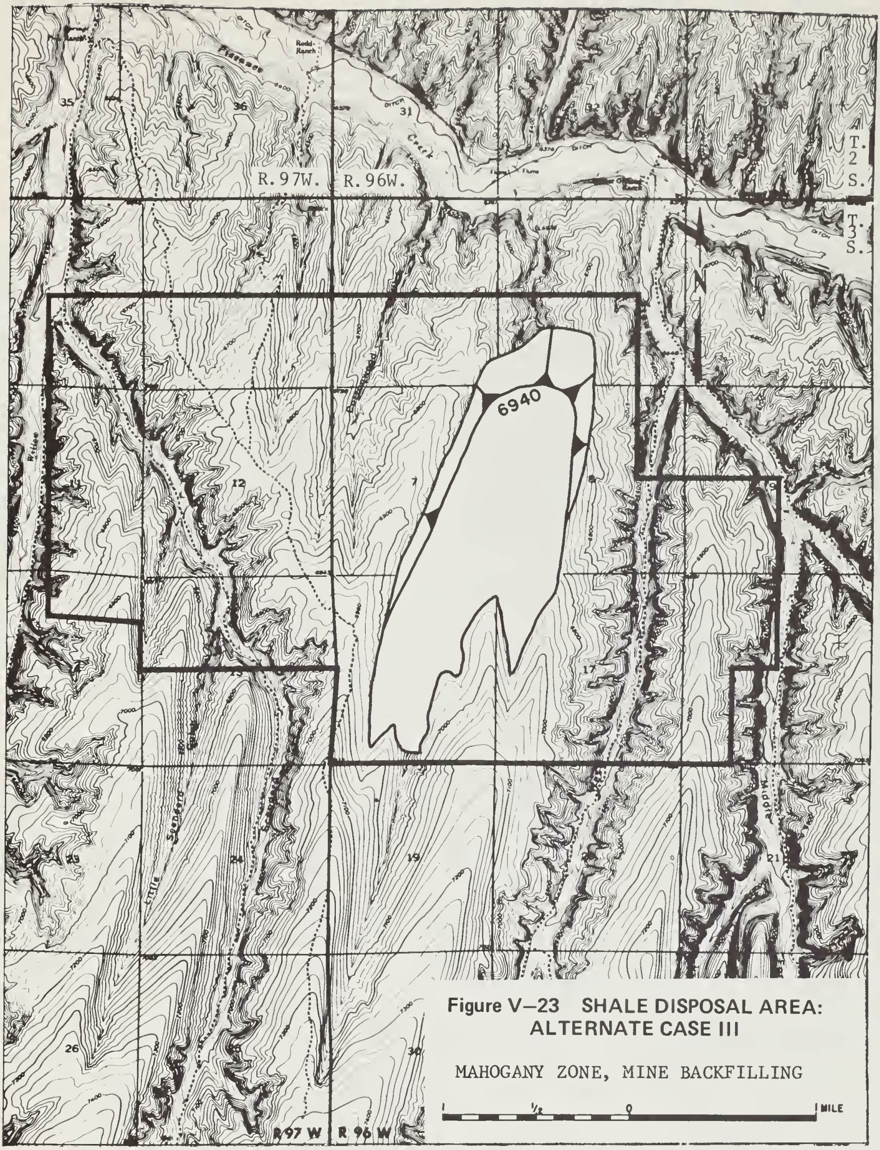


Figure V–23 SHALE DISPOSAL AREA: ALTERNATE CASE III

MAHOGANY ZONE, MINE BACKFILLING

or 325 million tons, would be stored on the surface. This can be done by filling Sorghum Gulch to elevation 7050 feet on-tract (See Figure V-24).

Failure of tailings piles, dams and waste dumps in various locations in recent years has created apprehension among landowners downstream from such structures. Damage to streams and flood plains associated with these failures is of environmental concern. Such failures also pose a threat to public safety. Construction of a processed shale disposal embankment has been studied by geotechnical consulting firms. Extensive laboratory testing of processed shale under various static loadings and degrees of saturation was performed to define its material strength. Dynamic tests were run to simulate seismic loadings which might be expected from natural events or from nuclear gas-stimulation activities. The proposed processed-shale disposal pile will be located in an area of moderate seismicity (Uniform Building Code Zone 1). The tests performed indicated a need to control placement, density and slope.

A study was performed to determine the liquefaction potential of a 1000-foot-deep processed-shale embankment. This study was prompted by concern over the potential for "liquefaction" slides which can occur in deposits of fine sand and silt and in various clays. Such slides usually occur when an embankment is completely water-saturated at the time of placement and when the weight of the pile is supported by the water in the pores between the grains in the pile rather than by the grains themselves. When such a condition exists, the entire mass could flow as a liquid when subjected to shock loading. This type of flow or slide can be avoided by proper control of placement procedures. The study recommended processed-shale placement densities of 85 pounds per cubic foot dry density for the interior 80% of the embankment, and 90 pounds per cubic foot dry density for the frontal 20%. These densities can be obtained when the placement moisture content is approximately 13%. A pile constructed in accordance with these parameters would not become saturated until the water content reaches approximately 28%. Liquefaction studies have also determined that even if portions of the pile were to become completely saturated, a flow-type failure would not result from dynamic loading, although some local sloughing, slumping and bulging could occur.

The effects of dynamic shock loading produced by nearby underground nuclear blasts were also considered with a view toward what could happen to the pile under the worst conditions. The study assumed an average compaction density of 85 pounds per cubic foot, full saturation of the pile, and a water table elevation at the surface of the pile. The study concluded that a nearby underground blast of 100-kiloton yield could liquefy the processed shale if the shock were at slant distances of less than 8 to 15 kilometers from the pile. However, even for this condition flow-type failure of the pile would not occur, although slumping or bulging of the slopes could be expected.

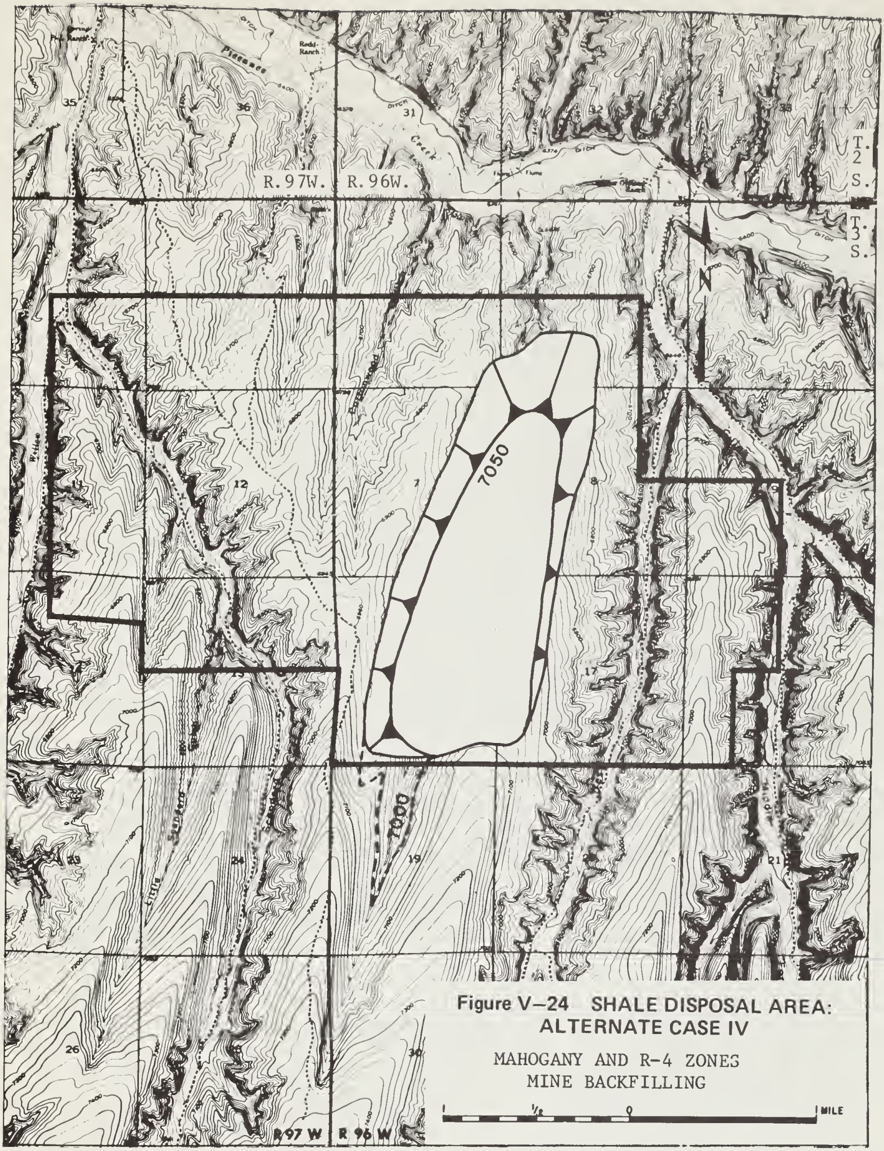


Figure V-24 SHALE DISPOSAL AREA: ALTERNATE CASE IV

MAHOGANY AND R-4 ZONES
MINE BACKFILLING

Slope stability studies also have been conducted to evaluate the static stability of the proposed embankment, including the effects of dynamic loads on normal slope stability. This study found that processed shale compacted to dry densities of 85 to 90 pounds per cubic foot, at compaction moisture contents of 5% to 20% by weight, has an internal angle of friction equal to 35^{o} and a cohesive strength ranging from 900 to 2900 pounds per square foot. Upon saturation, the cohesive strength disappears and the angle of internal friction drops to about 20^{o}. Slope design for the commercial embankment will be based on the performance characteristics of fully saturated processed shale, although it is highly unlikely that significant saturation will occur because of the relatively low level of precipitation and the relatively high evapotranspiration rates, which substantially exceed annual precipitation rates in the area. Slopes will be constructed on a 4 horizontal to 1 vertical inclination (14^{o}), with horizontal benches at vertical increments of 25 feet or less. This design will assure a safety factor of at least 1.5 under the worst conditions.

During the five-year experimental operation of the Colony prototype plant, more than 100,000 tons of processed shale were produced. Fifty thousand tons of this processed shale were deposited in a compacted embankment near the retorting facility. This pile was used for testing a variety of compacting equipment including pneumatic-wheel, segmented-wheel and vibratory compactors. Test results enabled a determination of optimum moisture for handling and for compaction to specified densities. Of all the machines tested, the segmented-wheel compactor appeared to perform most satisfactorily. Moisture content ranging from 11% to 15% was found to be optimum. The test program produced dry densities of over 100 pounds per cubic foot, and demonstrated that the specified values of 80 to 90 pounds per cubic foot can be easily attained. These tests also showed that when the processed shale was moisturized to the optimum level, little dusting occurred while the compacting equipment was being operated.

Because of potential effects upon local climatology and upon plants used in revegetation, some concern has been expressed about the surface and interior temperatures of the pile. During preliminary tests conducted at the Colony prototype processed-shale embankment, shale was delivered to the embankment from the conveyor at a temperature of about 160^{o}F before being spread and compacted. Twenty-four hours later the temperature of the pile at a depth of three feet was found to be approximately 100^{o}F. The interior of the pile is expected to remain at about 100^{o}F for several years. If an earthen cover having a low thermal diffusivity is used and exposed to an average temperature of 70^{o}F, the mean temperature of the earth covering should be approximately 85^{o}F. The mean temperature of native rock in the area is 52^{o}F to 55^{o}F. Since the pile surface cools faster than the interior portion of the pile, no permanent effect upon local climatology is expected. The temperature of ground water in the immediate area may increase. In winter surface temperatures may prevent the accumulation of snow atop the piles. In the summertime, the surface temperature of the pile will be somewhat higher than the surrounding ground due to the relatively black color of the material and the resulting higher absorption of solar energy. The impact of higher temperatures resulting from surface color on revegetation activities is discussed in Section V. K., Erosion Control and Surface Rehabilitation Plan.

In the TOSCO II process, the oil shale is completely retorted and all of the oil and gas produced is recovered. The only other product is the processed shale, a finely divided inorganic material containing 3% to 5% organic carbon. Although virtually any material which contains a reactive fuel will combust spontaneously in the presence of adequate oxygen under certain temperature and oxidation conditions, the potential for spontaneous combustion for fully retorted processed shale from the Green River formation is virtually non-existent. By the time the processed shale is compacted, the moisture content will be about 13% by weight and the temperature will have cooled to around 100^{o}F or less. According to the U. S. Department of the Interior, the temperature required to initiate combustion in the presence of air is 878^{o}F for processed shale containing about 3 weight percent organic carbon. Since the processed-shale embankment will contain about 13 weight percent water and will be compacted to a density of 85 to 90 pounds per cubic foot, oxygen will not be able to penetrate the embankment in sufficient quantities to support subsurface combustion. The amount of trapped air and the pile temperature are insufficient to either initiate or sustain combustion. Surface temperatures are not expected to exceed 200^{o}F (the temperature at which the shale leaves the pyrolysis facility) under any circumstances.

Past experiences of Colony, The Oil Shale Corporation and the Bureau of Mines also support the above conclusion. In over 10 years of pilot plant and semi-works operations, not a single incident of spontaneous combustion of processed shale has ever been reported. Historically, in over 30 years of oil shale research on shale mined from the Green River formation there are no known incidents of spontaneous combustion involving processed shale.

e. Water Diversion and Control

The potential for pollution of surface and subsurface waters from rainfall and snowmelt through runoff, percolation and leaching has been recognized and studied. The studies have evaluated: the balance between precipitation, evaporation, runoff and plant usage; the implications of pile saturation and percolation; the potential for leaching various inorganic salts and heavy metals from processed shale; and the effects of freeze-thaw cycles on the surface of the pile. The pollution potential exists because surface runoff could contain suspended solids, high concentrations of dissolved solids (primarily the sulfate salts of sodium, potassium, calcium and magnesium) and trace quantities of some of the elements previously identified in Table V-19.

If percolation occurred within the pile, a similar pollution potential would exist for subsurface water. Laboratory and field studies have examined the relative leaching characteristics of the native soil, raw shale and processed shale. A large simulation study of the embankment included simulation of rainfall, snowfall, freeze-thaw cycles and underground spring saturation. The results of the tests have shown that: 1) runoff contamination consists of sediment and dissolved solids; 2) surface moisture can penetrate into the pile at a rate determined by the initial moisture content and the rate of water application; 3) the depth of water penetration into the pile, under local weather conditions, should be limited to the top five feet of the bed; 4) because of the limited water penetration, no leachate will be produced except at the edges of the pile where shale thickness is less than five feet; 5) the small amount of leachate produced will contain primarily the inorganic salts leached from the processed shale; 6) the dissolved solids content of the leachate should diminish with time as repeated leaching cycles occur as a result of natural weather cycles; 7) surface degradation by wind and water erosion can be controlled by maintaining a moist surface through water irrigation, revegetation or by other stabilization methods; 8) surface degradation by freeze-thaw cycles will occur only if the surface of the pile is saturated during the freeze cycle; and 9) freeze-thaw degradations of a saturated surface will be limited to a very thin surface layer (about 1/8-inch thick), with no effect on density or other properties below this thin layer.

The horizontal benches on the front slope of the embankment will slope toward the embankment at a 10% slope, leading to downslope drainage flumes which will convey the runoff down and away from the embankment. The benches will contain a sealed invert to convey the water while retarding erosion. The drainage system will be designed for the 100-year flood and will be installed so as to produce minimal damage to the embankment if design flows are exceeded. Drainage flumes will be 3 to 4 feet in width, depending upon the area drained. Larger-size or duplicate flumes will be installed to route runoff from the top of the embankment and surrounding watershed along the interface between the lateral shale and natural surfaces. This will minimize erosion and preclude excessive infiltration at the interface.

The exact location and number of flumes will depend upon the shape and surface area of the embankment face. Spacing will be approximately 400 feet between downslope flumes. Drainage will be toward the outside limits of the embankment, where central flumes will join the outside ones. Transition sections and energy dissipators will be installed as required near the top of the embankment. Small settling basins will be constructed to remove the suspended solids from the main flow to the catchment basin. These will be cleaned periodically as necessary (Figures V-25 and V-26).

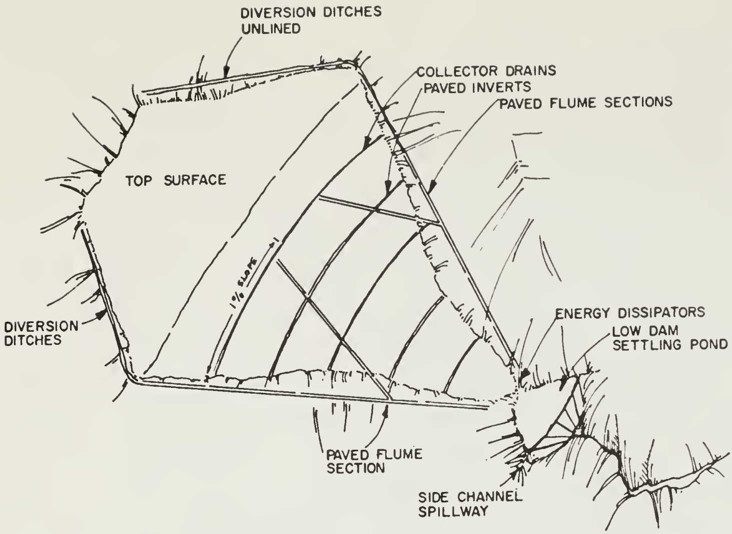


Figure V–25 DRAINAGE SYSTEM OF PROCESSED SHALE PILE

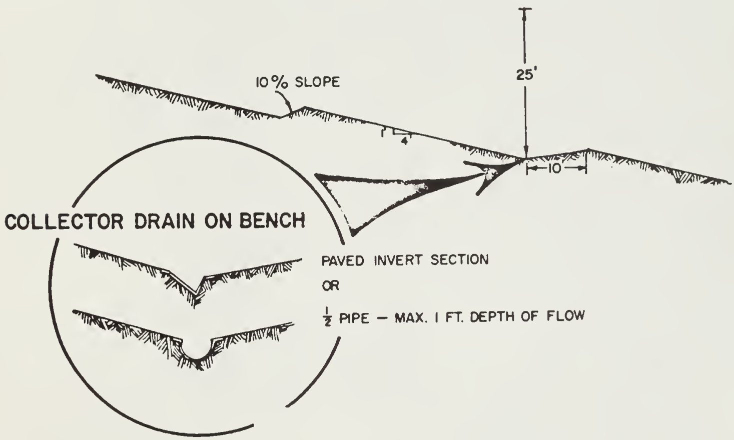


Figure V–26 TYPICAL SLOPE SECTION OF PROCESSED SHALE PILE

Because the emplacement of processed shale will take place in a step-by-step manner, it is envisioned that the revegetation program will also proceed by phases. A further description of the revegetation phases and procedures is given in Section V. K., Erosion Control and Surface Rehabilitation Plan.

f. Stabilization and Rehabilitation

The procedures described in Section V. K. will be utilized throughout the processed-shale disposal activities to insure compliance with environmental criteria and controls required by the Lease.

OTHER WASTES

V. I. Disposal of Other Wastes

1. Summary of Activities Producing Other Wastes

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

   a. Lease Requirements and Applicable Regulations
   b. Lessee's Plan for Disposal of Other Wastes

      (1) Construction
      (2) Crushing Unit
      (3) Pyrolysis Unit
      (4) Upgrading Facilities

         (a) Naphtha and Gas-oil Hydrogenation Units
         (b) Hydrogen Unit
         (c) Sulfur Unit
         (d) Gas-treating Unit

      (5) Water Treatment Facilities

         (a) Raw-water Treatment
         (b) Runoff and Oily-water Treatment
         (c) Sanitary Sewage Treatment

      (6) Miscellaneous Wastes
      (7) Disposal of Liquid Wastes

V. I. Disposal of Other Wastes

During the operations on the Tract, solid and liquid wastes other than overburden and processed shale also will be generated. This plan describes the various types of other waste material that will be produced, reviews the applicable Lease terms pertaining to disposal of these substances, and details the Lessee's plan for compliance.

1. Summary of Activities Producing Other Wastes

During Phase I and Phase II, much of the wastes generated will consist of slash from the clearing of construction sites. Lesser quantities of other wastes which include sewage, trash, garbage and liquid petroleum wastes from the development mining and construction activities, will also be disposed of.

During Phase III, most of the wastes will be generated by the plant facilities. Dust will be produced by the crushing unit (425 tons per day) and pyrolysis unit (975 tons/day). About 1,000 tons of spent catalyst material will be generated each year by the upgrading, hydrogen and sulfur units. The gas-treating unit will annually produce about 200 tons of waste diatomaceous earth and about 200 tons of deactivated carbon. Water treatment facilities will produce small amounts of additional waste material. Sanitary sewage effluent and miscellaneous trash and garbage will be produced in quantities commensurate with the size of the facilities.

Many of these substances may have potential commercial value and will be reclaimed. Others are strictly waste material. However, many of these materials could be potentially damaging if allowed to escape untreated into the environment and might pollute the air and water and be hazardous to public health and safety.

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Control and Compliance

a. Lease Requirements and Applicable Regulations

The Lease itself does not contain any detailed instructions for the disposal of other wastes, but instructions and references for their disposal are contained in the Lease Stipulations. The Stipulations, as well as federal, state and local standards and guidelines for the disposal of such wastes, are listed and summarized in Table V-22.

Table V-22 STANDARDS FOR WASTE DISPOSAL, OTHER THAN PROCESSED SHALE AND OVERBURDEN

Source	Reference Subject
Oil Shale Lease Environmental Stipulations	Section 3: Disposal of flammable liquids, gases and solids
	Section 7: Approval of disposal sites or techniques to handle spilled material
	Section 8: Burning
	Section 9: Control of Waste
	Section 23(C): Permission to clear and strip land for disposal operations
	Section 14(B)-(E): Other disposal area instructions and references; disposal of solid and liquid wastes; impoundment of water and slurry waste disposal instructions
State (Colorado)	Colorado Mining Laws with Safety and Health Rules and Regulations, Bulletin 20 (Section 26 and 134)
	Colorado Solid Waste Disposal Sites and Facilities Law (Chapter 36, Article 23, CRS 1963 (Vol. II Perm. Cum. Supp. as Amended in 1971 by Senate Bill (132), Effective July 1, 1971)
	Colorado Solid Waste Regulations (Colorado Regulations, Solid Waste Disposal Sites and Facilities; Adopted February 16, 1972; Effective April 1, 1971)
United States Public Health Service	42 CFR Chapter I (Reference from 30 CFR Part 231.25)
Department of Interior, Mining Enforcement and Safety Administration	30 CFR Chapter I, Parts 55, 56, 57 (Reference from 30 CFR Part 231.25.)
Department of Interior	43 CFR Part 23 Mining Plan Requirements

A description of plans to conform with Section 311 (a)(14) of the Federal Water Pollution Control Act as amended (86 Stat. 816, 863), and the National Oil and Hazardous Substances Pollution Contingency Plan, 36 FR 16215, August 20, 1971, can be found in Section V. L., Oil and Hazardous Materials Spill Contingency Plan.

b. Lessee's Plan for Disposal of Other Wastes

It is anticipated that much of the waste, both solid and liquid, will be disposed of with the processed shale. It is the Lessee's intent to use the best practicable portable or permanent waste disposal systems and to have all plans, disposal sites and disposal activities described in this DDP approved by the AOSS.

The following is a brief discussion of the waste generated from and by each processing unit and other sources of waste, along with a discussion of the disposal of these waste materials. A listing of the solid waste materials which will be produced in the shale oil complex is presented in Table V-23.

(1) Construction

During the early phases, large quantities of slash consisting of small trees and brush will be cleared from the surface of all construction sites. All trees, snags, stumps or other vegetation not having commercial, wildlife or construction value will be considered for mechanical chipping and spreading in a manner that will aid seed establishment and soil stabilization. Depending upon the quantity of material involved, it may also be necessary to burn some of it (in accordance with the guidelines in Section 8(C) of the Stipulations) or to bury it at the site of the processed-shale pile in Sorghum Gulch. During plant and mine construction, miscellaneous waste building materials such as wood, metal, concrete, wire and waste paper will be gathered and probably buried at the processed-shale disposal site.

(2) Crushing Unit

A total of 425 tons per day of raw-shale dust will be generated in the crusher units. The primary crusher, which will be located in the underground mine, will generate approximately 25 tons per day of raw shale dust. This dust will probably be collected in a bag house dry-type dust collection system. An additional 325 tons per day of oil shale dust will be collected in a bag house dust collection system at the final crushing facility. If a silo is used to store the fine-crushed shale, an additional 75 tons per day of oil shale dust will be collected.

Two options exist for the disposal of the raw shale oil dust: 1) it can be disposed of along with the processed shale, or 2) it can be fed to the pyrolysis unit preheat system where it will exit as either

Table V–23 MAJOR SOLID WASTES

(Other than Overburden and Processed Shale
for a 50,000 BPD Retorting & Upgrading Complex)

Source of Solid Waste	Approximate Quantity	Major Constituent
Pyrolysis Unit		
Clarifier Sludge from Wet Scrubbers-Preheat System	860 T/D (water excluded)	Raw Shale Dust
Ball Circulation System	65 T/D (water excluded)	Processed Shale Dust
Processed Shale Moisturizing System	40-50 T/D (water excluded)	Processed Shale Dust
Crushing Unit		
Primary Crusher	25 T/D	Raw Shale Dust
Secondary Crusher	325 T/D	Raw Shale Dust
Shale Storage Silo	75 T/D	Raw Shale Dust
Upgrading Units		
Naphtha Hydrotreater	75 T/yr.	Spent HDN Catalyst
Naphtha Hydrotreater	60-80 T/yr.	Proprietary Solid
Gas Oil Hydrotreater	230 T/yr.	Spent HDN Catalyst
Gas Oil Hydrotreater	300-500 T/yr.	Proprietary Solid
Hydrogen Unit		
Hydrodesulfurizer	55 T/3 yrs.	Spent HDS Catalyst
Guard Bed	20 T/3 yrs.	Spent ZnS Catalyst
Shift Converter (High Temp.)	50 T/5 yrs.	Spent Fe-Cr Catalyst
Shift Converter (Low Temp.)	50 T/3 yrs.	Spent Cu-Zn Catalyst
Sulfur Unit		
Claus Unit	160 T/2 yrs.	Spent Alumina Catalyst
Gas Treating Unit		
DEA Filter	8.25 T/2 wks.	Diatomaceous Earth
DEA Filter	8.25 T/2 wks.	Deactivated Carbon

processed shale or as wet scrubber sludge. Because the oil content of the dust is 20% less than the average mine run oil shale and because of problems of operation, it is not feasible at the present time to process the oil shale dust from the crusher units.

(3) Pyrolysis Unit

In addition to the 20 million tons per year of processed shale, the pyrolysis unit for a 50,000 BPD shale oil complex also will produce a thickened sludge from a clarifier. The sludge, which will be disposed of continuously with the processed shale, contains solids collected in the preheat system scrubbers, the ball circulation system scrubbers and the processed-shale moisturizing system scrubbers. About 275 tons per day of raw and processed-shale sludge (water included) will be placed on the processed-shale conveyor for disposal in the processed-shale embankment. The raw-shale sludge collected from the preheat system has a very low oil content and a very small particle size. Thus it is not feasible to process this material (in the form of clarifier sludge) in the pyrolysis unit.

(4) Upgrading Facilities

Two cases are being considered for upgrading of pyrolysis products. One case assumes that the crude shale oil would be hydrotreated for reduction of sulfur and nitrogen content, and that retort off-gases would be treated for removal of hydrogen sulfide prior to use as in-plant fuel. The other case provides for treating of the retort gases, but includes only minimal treatment of the liquid products in order to make them amenable to pipelining. In the following sections, the hydrotreated-oil case is considered to be the most likely or "base" case, with some possible variations also discussed. It should be emphasized that actual waste types and quantities cannot be determined with precision prior to a definitive engineering design.

(a) Naphtha and Gas-oil Hydrogenation Units

If hydrotreated oil is produced, separate hydrogenation units would probably be used for naphtha and gas-oil fractions. About 75 tons of spent hydrodenitrogenation (HDN) catalyst from the naphtha hydrotreater and 230 tons of spent HDN catalyst from the gas-oil hydrotreater will be disposed of once every year. Depending upon the economic value of HDN catalyst, it either will be shipped out of the plant for reprocessing or disposed of in the processed-shale embankment. Reprocessing is more desirable environmentally and is a common practice at petroleum refineries. Reprocessing can be done economically with nickel-based or other relatively expensive catalysts. Cheaper catalysts such as cobalt molybdate would likely be disposed of. The composition of HDN catalyst which could be used in these units is given in Table V-24.

Table V–24 APPROXIMATE COMPOSITION OF SPENT HDN CATALYSTS

CONSTITUENT	WEIGHT PERCENT	
	Naphtha Hydrotreater	Gas Oil Hydrotreater
Inert alumina filler	7	7
HDN catalyst*	78–68	75–61
Carbon	7–10	10–15
Sulfur	8–10	8–10
Arsenic	0–5	0–7

* The catalyst composition is considered proprietary information by the manufacturer.

Table V–25 TRACE METALS FOUND IN RAW SHALE OIL

Antimony	Mercury
Arsenic	Molybdenum
Beryllium	Nickel
Boron	Potassium
Cadmium	Rubidium
Calcium	Selenium
Chromium	Silver
Cobalt	Sodium
Copper	Strontium
Fluorine	Tellurium
Germanium	Titanium
Iron	Vanadium
Lead	Yttrium
Magnesium	Zinc
Manganese	

The spent HDN catalysts will also contain trace amounts of nickel, vanadium, arsenic and other metals which are picked up from the raw shale oil. These metals are listed in Table V-25. Because of the small quantities of these metals and the small amounts of spent catalyst to be deposited in the shale pile, relative to the total amounts of processed shale to be deposited (20 million tons per year), the impact of the disposal of this material is expected to be insignificant.

A proprietary process will be used to remove arsenic from the naphtha and gas-oil hydrotreater feed streams, since the amount of arsenic in these streams would quickly de-activate the hydrotreating catalysts if not removed. The arsenic removed from the feed streams is ultimately concentrated in solid form in combination with an inert compound. About 60 to 80 tons per year of arsenic-containing waste material from the naphtha hydrotreater, and about 300 to 500 tons per year from the gas-oil hydrotreater, will be disposed of in the processed-shale embankment. The approximate composition of this waste material is given below:

Hydrotreater Waste Material	Wt.%
Inert compound (35% Sulfur)	80
Arsenic	20

The arsenic will be in a form which is quite insoluble in water at ambient temperatures. This waste material from the hydrotreaters will contain 20% arsenic or about 72 to 116 tons per year. Approximately 30 parts per million of the total waste material is water soluble and amounts to about 22 to 35 pounds per year. The small amount of water-soluble arsenic in this hydrotreater waste material represents about 1/125 to 1/200 of the water-soluble arsenic present in the processed shale. Processed shale contains about 50 PPM of arsenic, of which 0.22% (0.11 PPM) is water soluble. Considering the small amount of water-soluble arsenic to be added to the relatively large volume of processed shale (20 million tons per year), the environmental impact resulting from the deposit of this material is expected to be insignificant. The arsenic-containing waste material will be removed from the hydrotreater units in the same manner as the hydrotreating catalysts.

A proprietary process designed to remove catalyst and waste material from process units is currently being developed. The disposal procedures to be used at the processed-shale embankment will depend upon the final design of this process.

The preferred catalyst waste-material removal process would require liquid flooding of reactors and gravity discharge of catalysts into a transportable, sealed container. In such a system, the waste material would exist as a slurry of granular solids and waste. This slurry waste would not be of sufficient volume to induce landslides, mudflows or waste-pile blowouts. However, an impoundment sufficient to contain landslides, mudflows or waste-pile blowouts from this slurry disposal will be provided.

The procedure for discharging wastes from the sealed containers into the processed-shale embankment or other disposal area has not been engineered in detail. Dilution of spent catalysts and solid waste within processed shale will be maximized. One feasible method for disposal being considered includes digging a relatively small trench in the processed-shale pile and spreading the contents of the sealed containers down the length of the trench. Partial dewatering of the slurry would be required before dumping into the trench. The trench would then be covered and compacted before the moist, granular solids dry completely. In this manner spent catalyst would be uniformly spread throughout the processed-shale pile.

There are several methods of handling the arsenic-containing waste material which could be considered as alternates to disposal in the processed-shale pile. One method would be to transport the material to another off-site disposal area. This method, however, would likely have no advantage over the disposal in the processed-shale embankment.

A second method would be to seal the spent catalyst material in cement-filled drums prior to disposal in the pile. This approach may be impractical due to the large volume of material produced.

A third method would be to recover the arsenic prior to disposal. This method might be less acceptable environmentally than the disposal of the untreated material directly into the processed shale. Existing arsenic recovery technology itself produces significant environmental and hygiene problems. Therefore, considering the low permeability of the processed-shale embankment and the large amount of processed shale compared to the relatively small amount of arsenic-containing waste, mixed disposal in the processed-shale embankment is currently preferred.

(b) Hydrogen Unit

Four different solid wastes will be produced in the hydrogen unit: hydrodesulfurization (HDS) catalyst; guard bed catalyst; high-temperature shift catalyst; and low-temperature shift catalyst.

About 55 tons of HDS catalyst, probably cobalt molybdate, will be disposed of once every three to five years. This catalyst has no reprocessing value and will be disposed of in the processed-shale embankment.

About 20 tons of guard-bed catalyst, primarily zinc sulfide (ZnS) plus some zinc oxide (ZnO), will be disposed of once every three years. This catalyst will be reprocessed to recover the zinc if a reprocessing contract can be arranged. Otherwise, the spent catalyst will be disposed of with the processed shale.

Fifty tons of high-temperature shift catalyst, a mixture of iron and chromium oxides, will be disposed of about once every five years. Preliminary analyses indicate that it may be economical to reprocess this solid waste for the chromium. If not, it will also be deposited in the processed-shale embankment.

Approximately 50 tons of low-temperature shift catalyst will be disposed of once every three years. This catalyst is made up of copper and zinc oxides and will probably be shipped out for reprocessing. Otherwise, it will be disposed of with the processed shale.

If it proves desirable to transport crude shale oil to market, rather than a hydrotreated product, then a hydrogen plant would not be required and the above wastes would not be generated.

(c) Sulfur Unit

The sulfur unit yields one solid waste: Claus-unit catalyst. The spent Claus-unit catalyst consists of a deactivated alumina which will be mixed with the processed shale for disposal. The estimated disposal quantity is about 160 tons every two years. If minimal hydrotreating is used, this quantity would be reduced but not eliminated, since sulfur would still be recovered from the retort gases.

(d) Gas-treating Unit

The most probable method of gas treating is the use of conventional amine absorption technology; other potentially applicable methods include the hot carbonate process and the Rectisol (cold methanol) process. The environmental impacts of these processes are comparable, but the use of diethanolamine (DEA) absorption currently appears to be most reliable and economical.

If used, the DEA system in the gas-treating unit will contain two filters to remove impurities from the DEA. The first filter will use a diatomaceous earth precoat. About 8.25 tons of diatomaceous earth will be disposed of in the processed-shale embankment every two weeks, or about 215 tons annually. The second filter will contain activated carbon to absorb hydrocarbons from the DEA. The spent activated carbon will either be sold or disposed of in the processed-shale embankment. About 8.25 tons every two weeks, or 215 tons annually, of this spent activated carbon will be generated for sale or disposal.

(5) Water Treatment Facilities

The water treatment facilities will perform three distinct functions: 1) raw-water treatment, 2) treatment of runoff water from the process area and from the oily-water sewer system, and 3) sanitary sewage treatment.

(a) Raw-water Treatment

Water for operations on the Tract will come from on-tract mine dewatering, with additional water imported from the Colorado River or White River. Under the presently preferred plan, mine water and additional imported water from the Colorado River would first pass through a sedimentation and clarification process to remove sediment, followed by partial softening using flocculents and lime. The lime sludge will be pumped as a slurry to the pyrolysis unit for eventual use in moisturizing processed shale. Waste streams from the cooling-water makeup system, potable-water treatment system, and boiler feed water system will include zeolite regeneration wastes, boiler blowdowns and cooling-water blowdowns. These will ultimately be disposed of on the processed shale. Flocculents, coagulents and chemical additives will vary for each water source, depending on the mineral composition of the water. In any case, waste streams from the water treatment facilities will be disposed of with the processed shale. The Lessee will not discharge contaminated waste water to any natural stream.

(b) Runoff and Oily-water Treatment

The waters and chemicals collected from such sources as leaks, drain outs, flushes, wash downs and storm runoff in the process area will flow through the oily-water sewer system to an oil-water separator. A surge pond will be provided to handle large quantities of water during a period of high storm runoff. Water in the surge pond can then be consumed in the process as the sewer flow subsides. The oil will be skimmed from the water and recycled to the oil recovery unit. Solids collected in the oil-water separators and holding basin, primarily sand, eventually will be sent to the processed-shale pile. The clarified water from these units will be used to moisturize processed shale. Grimy waste water from the mine shops will be collected in tanks and transported to the plant oil-water separator.

(c) Sanitary Sewage Treatment

The surface sewage treatment facilities will be designed to meet all applicable governmental regulations and the requirements of the Lease Stipulations, and be in accordance with good engineering practices. During Phase I, an aerobic sewage system will be installed on-tract to process sewage from surface operations and, later in Phase I, to process sewage collected from the development mine. This system will have a larger capacity than the maximum needed for the anticipated numbers of people required for the development mining phase. When the mine goes into the commercial stage, the mine sewage system will probably be tied into the overall plant sewage system. Current plans are to have a sewage collection system in the commercial mine. Waste from this system will be collected and transported to the surface and processed with the sewage from the plant complex.

During Phase II, sanitary sewage facilities will be provided by several means. Early in the construction phase, a system of chemical toilets and a septic tank system with a leach field may be used in conjunction with the existing mine surface sewage system. As construction progresses, a combination of portable sanitation facilities with handling tanks, chemical toilets and package aeration plants with leach fields will probably be used. If feasible, the permanent sanitary sewers and treatment plant will be installed at an early date. Holding tanks and chemical toilets will be pumped out periodically and the waste disposed of through normal commercial means.

The sanitary sewage system will collect sewage from all maintenance, mining, operations, laboratory, safety and security facilities. Effluent from the sewer will be treated in an aeration plant. The aeration plant will produce a clarified water and sludge.

In the current operating plan, sludge from the aeration plant will flow to a sludge surge tank and then to a processed-shale moisturizer in the pyrolysis unit. The sludge will ultimately be mixed with the processed shale and be disposed of with it at the disposal site.

An alternate method of disposal would require drying the sludge and disposal as a solid in the processed-shale embankment. The dried sludge constitutes an excellent amendment to processed shale and would be quite useful for adding nutrients and conditioning processed shale prior to revegetation.

Clarified water from the aeration plant will be treated in a hypochlorination unit and then discharged into the clean-water guard pond. Effluents from the clean-water guard pond will be used as make-up water for the processed-shale moisturizer. There will be no discharges from any of these units into Piceance Creek.

The aeration system has not been finally designed and the exact quantity of sludge and clarified water to be produced are not known. An estimated 20,000 to 25,000 gallons per day of clarified water may be produced.

(6) Miscellaneous Wastes

The mine and plant complex will be a source of miscellaneous wastes, trash and garbage normally produced by large manufacturing facilities. Based on current estimates, this material will amount to about 25 tons per day and will be added to the processed-shale embankment, which will be operated and maintained to meet sanitary landfill requirements. If the processed-shale embankment cannot be operated as a sanitary landfill, then an alternate disposal site will be used.

(7) Disposal of Liquid Wastes

This section will briefly discuss the disposal of liquid wastes not covered in the previous paragraphs. The pyrolysis unit will produce several liquid waste streams, with water as the main liquid constituent.

Wash water will be added to cooled effluent from the naphtha and gas-oil hydrogenation reactors to remove major quantities of ammonia (NH_3) and hydrogen sulfide (H_2S) formed during the hydrogenation reactions. The wash water will be separated from reactor effluent by gravity separation and pumped to the ammonia separation unit. After ammonia and hydrogen sulfide removal, the wash water will be recycled back to the hydrotreaters.

The ammonia separation unit will be designed to eliminate the discharge of sour water with a high ammonia content. The H_2S from this unit will be sent to the sulfur recovery unit. Stripped water will be recycled to the naphtha and gas-oil hydrotreaters to remove additional H_2S and NH_3. Excess stripped water will be sent to the pyrolysis unit for moisturizing processed shale.

If the Wellman-Lord SO_2 Recovery Process is used, as described in Section IV, to process the tail gas from the Claus trains, the waste streams from the process will include acidic quench water. It is neutralized with caustic and overflows to the oily-water sewer. A small stream of sulfite solution will continuously be purged to the pyrolysis scrubber makeup tank for eventual disposal with the moisturized processed shale.

Foul water from the delayed coker unit is removed in the coker fractionator and sent to the foul-water stripper. The water used for quenching and hydraulically cutting the coke is collected in a separator pit. Coke fines in the water will be removed by settling. The separated water will be then recycled for further quenching and coke cutting.

The foul-water stripper unit will remove H_2S and minor amounts of NH_3 from foul-water streams which leave the pyrolysis and oil recovery unit, the gas recovery and treating unit, and the delayed coker unit. The H_2S and NH_3 will be sent to the sulfur recovery unit where H_2S will be converted to elemental sulfur and NH_3 converted to nitrogen. The stripped water will be returned to the pyrolysis unit for moisturizing processed shale.

Foul unstripped water also could be used to moisturize processed shale. Emissions of ammonia and hydrogen sulfide from the surface of the embankment, however, could make compliance with applicable air pollution regulations more difficult. Another alternative would be to dispose of foul water in a deep disposal well.

Liquid petroleum waste from the development mining phase surface facilities will be collected and stored in approved containers. It will be transferred to a waste petroleum dealer for disposition.

For the commercial facility, liquid petroleum wastes from both the surface and underground shops will be transported to the upgrading units for reprocessing.

Any grimy water produced from the underground shop will be added to the mine sewage collection system for later transport to the surface and treatment in the plant complex's sewage facilities.

Fish and Wildlife Management

Fish and Wildlife Management

V. J. Fish and Wildlife Management Plan

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6. Operational Setting

Fish and Wildlife Management Plan

The development activities on Tract C-b will result in direct and indirect disturbances to fish and wildlife on and near the Tract. This plan describes: the development activities which will affect the habitat; Lessee's plans and procedures for controlling human activities which might affect wildlife; Lessee's programs for mitigating loss of habitat; and Lessee's implementation plans to comply with the Lease terms and applicable regulations.

1. Summary of Activities Affecting Fish and Wildlife

a. Phase I Mine Development

Phase I will result in limited activity on the Tract. The major effects of the proposed development mining operation will be changes to the habitat of small mammals and summer bird populations presently utilizing the surface areas which will be disturbed. Since the habitat in surrounding areas is similar, limited animal movement from disturbed areas will occur, with some repopulation and recolonization of the surrounding undisturbed areas. After rehabilitation and restoration of disturbed areas, repopulation and recolonization may proceed by immigration from surrounding undisturbed areas. Rapid reclamation upon cessation of the planned activities is important and should result in the land being able to support animal populations equivalent to those now present.

In the mine development phase, the greatest effect on the deer population will probably be increased road kills as a result of increased traffic.

Small mammals will probably undergo local population modifications and an overall reduction of numbers and density with habitat destruction. There will also be minor shifts in composition and diversity. For example, deer mice will probably increase while the sagebrush vole, which is at its southern limits of distribution, and the Apache pocket mouse, which is near its northern distributional limits, will likely diminish in number. There may also be a decrease in the abundance of the three species of chipmunk (the least, Uintah and Colorado), but at this time it cannot be predicted what changes will occur in these populations due to modifications in habitat.

Changes in habitat resulting from mine development and the presence of man will probably reduce, locally, the numbers of certain species of song birds. Birds such as the chickadees and pine siskins which inhabit wooded areas will probably stay away from the cleared areas where human activities are occurring. On the other hand, an increase in flock-like species such as horned larks that inhabit open areas will probably occur.

Raptor populations in the area may decrease, although raptor eyries and principal nest sites are not located close to mine development areas. If substantial changes in mammalian populations occur, changes may also occur in the abundance of certain raptor species. However, the small percentage of habitat to be disturbed relative to the total extent of similar habitats in the region suggests that local reductions in small mammal numbers should not have significant consequences on the habitat of wide-ranging raptorial species. As a result of the increased presence of man, poaching could have an impact on raptors.

Waterfowl and upland game birds will probably undergo minimal disturbance in Phase I, although poaching could affect both populations.

The preferred habitats of most reptilian species are the rocky, south-facing valley slopes and the densely vegetated valley areas near streams. Changes in these preferred habitats and, consequently, effects on these species, are expected to be negligible. There are no endangered reptilian or amphibian species in the area and no critical habitats that will be significantly damaged.

Fish and aquatic invertebrates should not be affected as a result of the shaft sinking and mine development since it is unlikely that the surface water flows will diminish. Piceance Creek has a high siltation rate during spring runoffs. Siltation resulting from erosion during construction activities will be controlled but some runoff may occur which could degrade water quality and adversely affect aquatic species, especially if occurring during fish spawning periods.

Spawning activities by game and non-game fish take place in Stewart Creek and Piceance Creek and probably to some extent in Willow Creek. Fish are more abundant in the streams in the vicinity of the Tract than in downstream stretches of Piceance Creek near the White River. Because of degraded water quality and unsuitable substrate in lower Piceance Creek, more fish probably spawn in the Tract vicinity and upstream of the Tract than in downstream portions of Piceance Creek near the White River. Brook trout spawn in the fall in the creeks and probably in lower Stewart Lake. Non-game fish spawn in the spring and summer in the creeks in the vicinity of the Tract.

b. Phase II Plant Construction and Phase III Plant Operations

Since the land disturbances caused by Phase II construction activities will extend into the Phase III operating period, the disturbances caused by these phases are discussed together.

Wildlife may be adversely affected by: 1) destruction or alteration of habitat and reduced quantities of forage as a result of land disturbance, particularly the construction of the processed-shale disposal embankment; 2) disturbance resulting from human and mechanical intrusion;

and 3) the possibility of poisoning as a result of accidental petroleum and toxic chemical spills. Clearing activities in pipeline and power-line rights of way and the increase in human population could also have a detrimental effect on animals. As an indirect consequence of development of the Tract, alterations in distribution and abundance of certain animal species are expected to result from increased road activity, hunting, trail biking and snowmobiling.

The access roads to the plant site and to the mine surface facilities represent hazards to mule deer because of the potential for road kills. The potential for road kills during most years will be highest during October and November and again during March and April, when areas in close proximity to the highway are most heavily used by large concentrations of deer.

Road kills, loss of browse species, and movement restrictions due to construction activities will probably have the greatest effect on the mule deer population. Unless controlled, harassment and poaching could also have serious consequences.

In addition to mule deer, other animals occasionally killed by road traffic include other big game species, small and medium-sized mammals, birds and reptiles. However, the cumulative adverse effect on these species of the proposed roads and traffic in the Piceance Creek area is expected to be minor.

A precise determination of the consequences of visual and audible disturbances of fauna is not possible because of the lack of behavioral information and the uncertainty regarding the degree of disturbance attributable to such factors. These disturbances will be local because they will not extend more than a mile from the source, except under very unusual circumstances. It has been found that deer adapt to human activity and noise. Operations at Colony's plant in Parachute Creek appeared to have had little influence on their overt behavior.

Medium-sized mammals, birds, reptiles and amphibians will experience approximately the same effects as during Phase I. The greatest effect will be reduced populations in localized areas where habitat has been disrupted. Introduced small mammal species, such as rats and house mice, may move onto the Tract, since they are associated with human activity.

Most of the influences on the aquatic communities will depend upon the degree of erosion, the extent of dewatering, and the storage, treatment and use of mine and imported water. Dust may also affect the water quality of local streams and ponds. Diminished stream flow resulting from mine activity would adversely affect aquatic communities.

c. Phase IV Post-operations

Disturbance during post-operation activities will be temporary.

Ultimate effects on fish and wildlife will be beneficial by return of disturbed areas to usable habitat.

2. Summary of Lease Requirements and Scope of the Plan

Section 4 of the Stipulations requires that the Lessee submit a fish and wildlife management plan for the following purposes:

- to meet the requirements of the Stipulations which state that "the Lessee shall submit ... a detailed fish and wildlife management plan which shall include the steps which the Lessee shall take to: 1) Avoid or, where avoidance is impracticable, minimize damage to fish and wildlife habitat, including water supplies; 2) restore such habitat in the event it is unavoidably destroyed or damaged; 3) provide alternate habitats; and 4) provide controlled access to the public for enjoyment of the wildlife resources on such lands as may be mutually agreed upon. The plan shall include, but not be limited to, detailed information on activities, time schedules, performance standards, proposed accomplishments, and ways and means of avoiding or minimizing environmental impacts on fish and wildlife."

- to provide information necessary to satisfy requirements of the Stipulations concerning mitigation of damage to fish or wildlife habitat, which includes the formulation of measures to "avoid, or, where avoidance is impracticable, minimize and repair, injury or destruction of fish and wildlife and their habitat; as a general rule, the proposed measures should provide for habitat of similar type and equal in quantity and quality to that destroyed or damaged."

- to provide information necessary to determine when and where it may be necessary to construct big-game drift fences in the vicinity of the Tract to direct big-game movements around or away from oil shale development areas.

This plan has been developed to provide a specific plan and procedures which can be used to avoid or minimize adverse effects on fish and wildlife caused by the development and operation of oil shale facilities on the Tract. Basin-wide and historical data, as well as the tract-specific data developed under the baseline data programs, have been used to formulate this plan. While basin-wide impacts on fish and wildlife from development activity must be considered, the procedures addressed in the plan must focus on the acreage of the Tract, specific areas of off-site activity, and other areas over which the Lessee has some degree of control. Wildlife and habitat management in the traditional sense is the province of governmental agencies such as the Colorado Division of Wildlife, the Bureau of Land Management, the Bureau of Outdoor Recreation, and the U. S. Fish and Wildlife Service. The most meaningful contribution of the Lessee to fish and wildlife management will lie in fully cooperating with these agencies and actively supporting future management plans for the Piceance Creek basin.

This plan will address activities on the Tract from the time of development planning to post-operation decommissioning. Within this time frame, fish and wildlife management plans for the development, construction and operation periods are considered.

Methods are included in the plan to provide for review and changes, as necessary, either to reflect changes in planned activities during development or to modify mitigation procedures if these should prove inadequate in the future or unnecessary.

The primary geographic scope of this plan is limited to the area of the Tract and to these areas of operational activity off-tract directly related to activities occurring on the Tract.

In implementing the Fish and Wildlife Management Plan, the Lessee will cooperate with governmental agencies and groups through the Area Oil Shale Supervisor, in accordance with the Stipulations.

3. Goals and Objectives of the Fish and Wildlife Management Plan

Objectives in formulating the Fish and Wildlife Management have been considered on two levels:

a. On-tract Considerations

Basin-wide historical information, along with the data being obtained in the baseline aquatic ecology and fauna studies have been utilized to analyze the significance of the Tract in the regional setting with respect to animal use and adjacent aquatic habitat.

The plan includes general policies as well as specific procedures to minimize adverse effects from development on fish and wildlife. Procedures are also included to enhance and maximize potential positive effects.

Negative effects expected to occur despite implementation of mitigation procedures have been estimated. Plans for providing alternate habitat and other special programs are also considered.

b. Regional Considerations

Records and historical data for regional terrestrial and aquatic wildlife habitats, population levels and fluctuations, and migratory movements have been reviewed.

General policies and specific procedures have been developed to coordinate plans with government agencies and appropriate private entities.

4. Implementation Plan

This section sets forth the general strategy which the Lessee plans to employ to minimize adverse effects on fish and wildlife from development of the Tract. It also addresses potential problem areas. Background information on wildlife and principal Tract habitats are contained in Section V.J.5. Potential problems, by species or groups affected, are shown on Table V-26. A more detailed review of schedules and potential impacts of specific activities appears in V.J.6.

The procedures discussed in this plan are based on present understanding of the wildlife effects which might be expected from development of the Tract. As development proceeds, the monitoring programs (Section VI) which are required by the Stipulations will give an indication of the effectiveness of the procedures. In the event that procedures are shown to require modification, these modifications will be made with the approval of the AOSS. Specific plans for mitigation of damage will be submitted for approval to the AOSS 60 days prior to a Lessee action which might result in significant damage or destruction of fish or wildlife habitat.

An Environmental Field Coordinator will be responsible for supervising the activities covered in this plan, for the life of the project. The field coordinator will insure that the specific tasks needed to achieve the goals of the plan are completed as specified. The field coordinator will also monitor the indicators used to evaluate whether a particular aspect of the plan is effective. Regulations concerning actions of personnel which might affect wildlife will be enforced by the field coordinator.

a. General Strategy

The area of primary development activity (Figure I-7) involves approximately 2000 acres in the central portion of the Tract. The 2000 acres utilized for mine surface facilities, plant site, processed-shale disposal, liquid and solid storage and related support facilities will undergo major modifications. Within this intensive development zone, revegetation and erosion control measures will serve to minimize the effects of development on wildlife. Revegetation work on disturbed areas and processed-shale disposal areas will emphasize plant species of importance to wildlife. However, the principal focus will be on the rapid establishment of vegetative cover and the consequent minimization of erosion. Details of the revegetation program are developed in the Erosion Control and Surface Rehabilitation Plan, (Section V.K.) and are not repeated here. Post-operation decommissioning will include revegetation plans for the eventual reestablishment of habitats to support a balanced number of types of native fauna.

The remaining 3100 acres of the Tract, which will not be directly involved in major development, will be subjected to habitat improvement

Table V–26 POTENTIAL PROBLEMS AFFECTING SPECIES GROUPS

X = Important Relationship
* = Wildlife Species Not Identified on Tract C-b but known to Occur Regionally

Specific Problem Areas

Important Wildlife	Significant Modification of Terrestrial Habitat	Erosion in Terrestrial Habitats	Modification of Aquatic Habitats	Erosion and Siltation Affecting Aquatic Habitats	Water Pollution Affecting Aquatic Habitats	Management of Water Quality Control Reservoir	Effects of Air pollution	Effects of Noise	Vehicle-Wildlife Collisions	Secondary Impacts resulting from growth in human population	Personnel Management	Access Management	Reduction in Ground-water Discharge affecting Terrestrial and Aquatic Habitat	Wildlife Disturbance Resulting from Human Activities
Mammals														
mule deer	X					X			X	X	X			X
desert cottontail	X	X												
bobcat	X									X	X			
coyote	X					X				X	X			
small mammals	X	X												
elk								X		X	X			X
beaver										X	X		X	
wild horse*														
mountain lion*								X		X	X			
ringtail*										X	X			
Birds														
waterfowl					X	X				X	X		X	
doves	X									X	X		X	
passerines & other small birds	X												X	X
raptors	X						X			X	X			
peregrine falcon*	X						X			X	X			
prairie falcon	X						X			X	X			
sage grouse*										X	X			
blue grouse*										X	X			
Fish														
brook trout			X	X	X									
rainbow trout			X	X	X									
forage fish			X	X	X									
cyprinids*				X										

procedures described in this plan. The primary objective of these procedures will be to increase carrying capacity for important species, in habitats comparable to those which will be removed or disturbed by the major development activities. Enhancement procedures will also provide habitat types which are presently limited or non-existent on the Tract. In this way, a variety of animal species may be expected to benefit. Species being primarily considered in this plan are those assigned high importance values in Table V-27 (see Section V.J.5.b below). Some examples of anticipated habitat enhancement procedures are: 1) increasing availability of water for waterfowl, big game, fish and semiaquatic species in Scandard Gulch and West Fork Stewart Gulch; 2) increasing the riparian habitats; 3) increasing productivity and vigor of browse species in selected areas in order to increase availability of food and cover for wildlife; and 4) placement of brush piles. In order for these measures to be effective, cooperative arrangements will be required with the Bureau of Land Management to permit management of livestock grazing in areas where habitat improvements are underway.

A major predicted consequence of the development of the Tract is an increase in vehicle-wildlife collisions. The data provided by the first year of the environmental baseline studies have shown that mule deer wintering in the vicinity of the Tract tend to congregate along the Piceance Creek road. During the fall, mule deer move from higher elevations into the meadows along the road. They remain in the vicinity throughout the winter, and cross the highway during their normal movements to and from feeding areas. This movement, combined with the increase in vehicular traffic, will require the installation of underpasses and deer-proof fences along a limited portion of Piceance Creek road close to the Tract and along the primary Tract access road. The amount of fencing involved and the use of underpasses will depend on the exact location of the access route to the Tract. This plan includes a tentative fencing design, based on general movement patterns of deer observed during the initial year of baseline investigations. Observations to be made during the 1975-76 winter might suggest modifications of the fencing and underpass plan.

Deer-proof fencing may also be required around areas of development in which untreated, low-quality water or other materials harmful to deer might be stored, and around the processed-shale disposal area during revegetation. In most cases this fencing would coincide with the location of the security fence for the development areas.

In the following section, the potential impacts which are anticipated from Tract development are identified, and proposed approaches to minimize or mitigate these impacts on fish and wildlife are described. Figure V-27 depicts the salient information on deer and raptors used in formulation of certain plan elements. This information was obtained during the first year's baseline investigations on the Tract. Figure V-28 shows areas proposed for habitat enhancement, pond creation, and deer-proof fence installation which are principal elements of this control plan. The location, size and number of facilities shown in

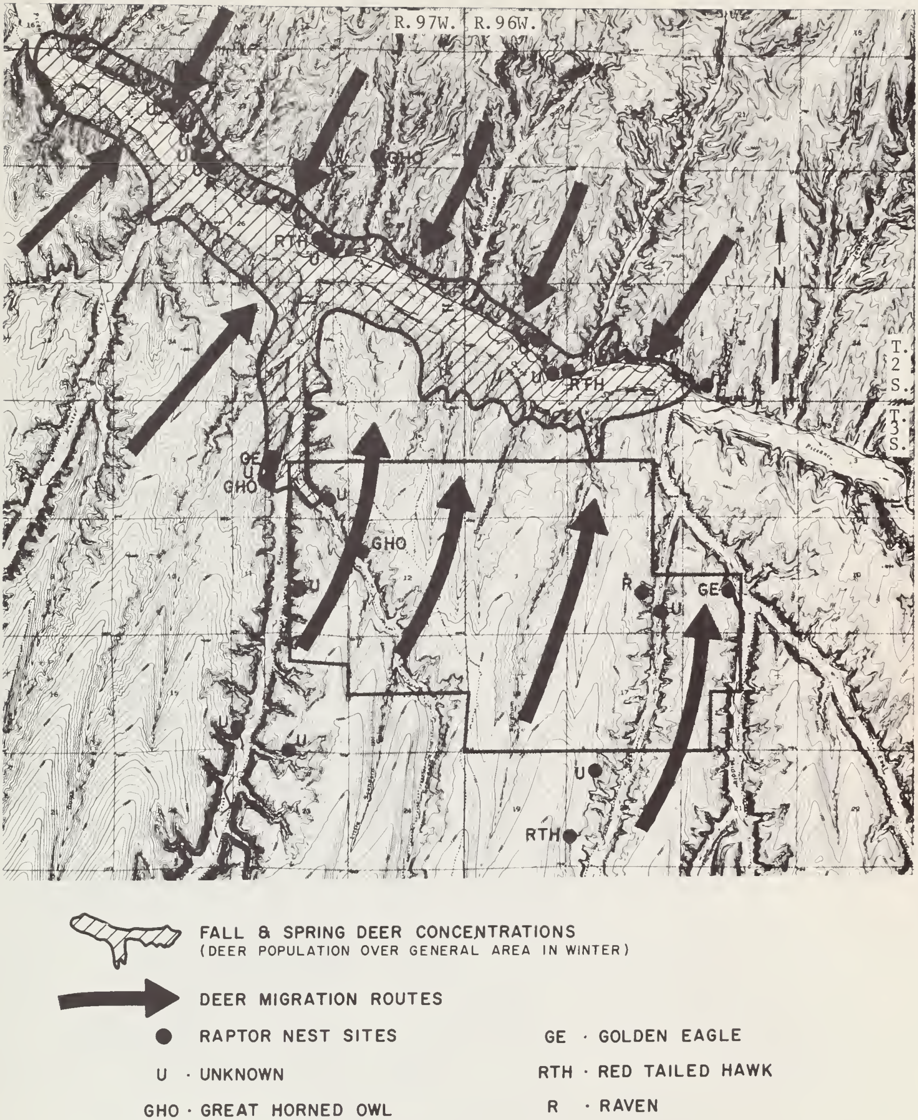
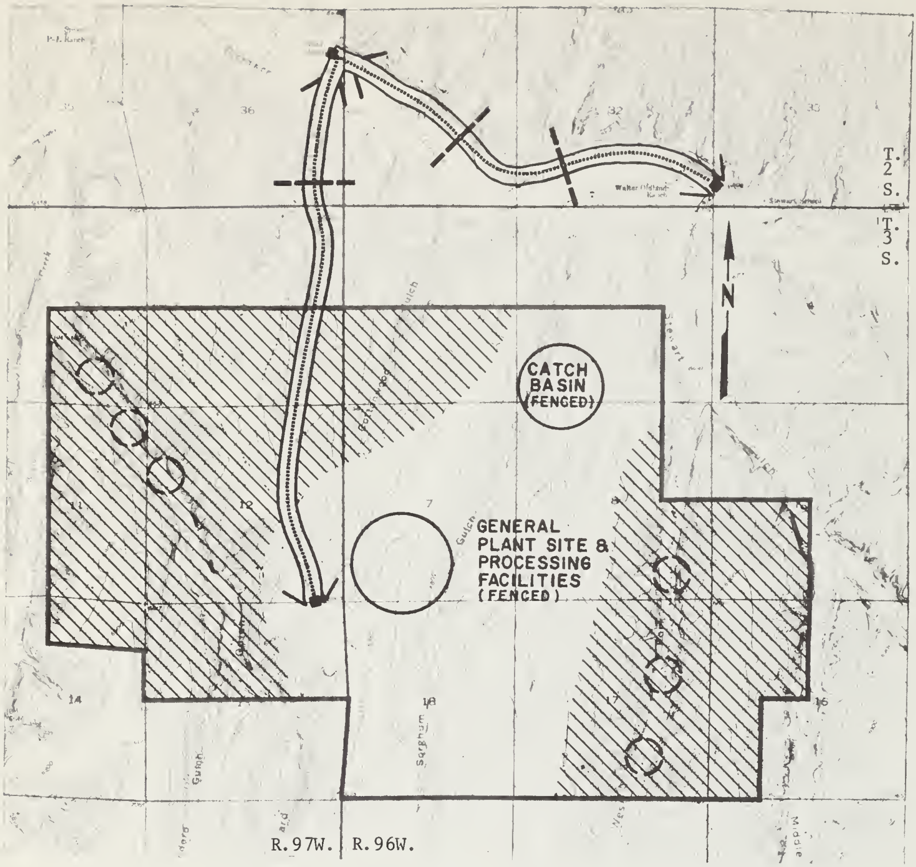


Figure V—27 DEER AND RAPTOR USE

Table V–27 IMPORTANT WILDLIFE IN THE VICINITY OF TRACT C-b
(Evaluations are ranked as H = high, M = medium, L = low, and are the subjective judgments of the Fish and Wildlife Management Committee)

Wildlife Species	Importance Criteria			
Only species, or groups (indicated by plurals), which are considered of possible importance are listed. For a complete listing of species see baseline wildlife studies.	Aesthetic visually attractive; rare, endangered, or threatened.	Economic game species, of agricultural significance	Ecologic herbivores, prey species, predators	Poisonous animals and Disease Vectors
Mammals of common occurrence on Tract C-b:				
Mule Deer	H	H	H	–
Desert Cottontail	M	M	H	L (Potential vector of Tularemia)
Bobcat	H	M Furbearers poten-	M	–
Coyote	L-H (controversial)	M tially important to	H	–
Raccoon	M	M sheep ranchers	M	–
Striped Skunk	M	L	L	L (Potential vector of Rabies)
Weasels	M	L	M	
Small Mammals:	M	M-L	H	–
Chipmunks				
Ground Squirrels				
Pocket Gopher				
Woodrat				
Mice				
Voles				
Shrews				
Muskrat	M	L	L	–
Porcupine	M	L	L	–
Bats	L	L	L	L (Potential vector of rabies)
Mammals of uncommon occurrence on Tract C-b:				
Elk	H	M	L	
White-tailed Jackrabbit	L	L	L	–
Badger	M	L	L	–
Beaver	H	M	L	–
Yellow-bellied Marmot	M	L	L	–
Mammals not identified on Tract C-b but known to occur regionally and which could be affected by oil shale development:				
Wild horse	H (Controversial)	L	L	–
Black Bear	M	M	M	–
Foxes	M	L	M	–
Mountain Lion	H	H	H	–
Ringtail	H	L	L	–
Birds of common occurrence on Tract C-b:				
Waterfowl:	H	M	L	–
Mallard				
Green-winged Teal				
Common Goldeneye				
Cinnamon Teal				
Blue-winged Teal				
Bufflehead				
Raptors:	H	L	H	–
Red-tailed Hawk				
Rough-legged Hawk				
American Kestrel				
Marsh Hawk				
Golden Eagle				
Great Horned Owl				
Mourning Doves	M	M	M	–
Passerines and other small birds:	M-L	M	H	–
Songbirds				
Woodpeckers				
Swifts				
Hummingbirds				
Shrikes				
Birds of uncommon occurrence on Tract C-b:				
Prairie Falcon	H	L	L	–
Bald Eagle	H	L	L	–
Cooper's Hawk	M	L	L	–
Goshawk	H	L	L	–
Birds not identified on Tract C-b but known to occur regionally, and which could be affected by oil shale development:				
Sage Grouse	M	L	L	–
Blue Grouse	H	L	L	–
Peregrine Falcon	H	L	L	–
Greater Sandhill Crane	H	L	L	–
Sharp-shinned Hawk	M	L	L	–
Reptiles and Amphibians of common occurrence on Tract C-b:				
Sagebrush Lizard	L	L	M	–
Northern Plateau Lizard	L	L	L	–
Reptiles and Amphibians of uncommon occurrence on Tract C-b:				
Short-horned Lizard	L	L	L	–
Gopher Snake	L	L	L	–
Wandering Garter Snake	L	L	L	–
Western Rattlesnake	L-M (Controversial)	L	L	M (Populations are low)
Fish of common occurrence on Tract C-b:				
Brook Trout	L	L Of potential	L	–
Rainbow Trout	L	L importance	L	–
Forage Fish	L	L	M	–
Mountain Sucker				
Speckled Dace				
Mottled Sculpin				
Fish not identified on Tract C-b but known to occur regionally, and which could be affected by oil shale development:				
Possibly three species of cyprinids: Colorado squawfish, humpback chub, and pahranagat bonytail	H	L	L	–



LEGEND

(double line)	8 FOOT DEER-PROOF FENCING	■	CATTLE GUARD
(hatched box)	GENERAL AREA OF HABITAT IMPROVEMENT	....	ACCESS ROAD
▬ ▬ ▬	TENTATIVE UNDERPASS LOCATION	(dashed circle)	TENTATIVE LOCATION OF PONDS
(arrow line)	ONE WAY EXIT GATES		

NOTE: Locations, sizes and number of facilities shown are conceptual only and subject to change.

Figure V—28 SCHEMATIC OF WILDLIFE MANAGEMENT PLAN TO MITIGATE DEVELOPMENT IMPACT

Figure V-28 are illustrative of the scope of Lessee's plan. However, final details will not be determined until project design is completed.

b. Potential Problem Areas

(1) Modification of Terrestrial Habitats

Complete modification of terrestrial habitats will occur during the filling of reservoirs, during the covering of productive biotic communities at the processed-shale disposal site, and during preparation for the construction of roads and facilities. Such modifications will render the particular sites unsuitable for wildlife. Reduction of terrestrial habitats will continue to occur throughout mine development, plant construction and operation periods, and will affect approximately 2000 acres. Most site development and all construction activities will contribute to the modifications. In addition to these major modifications, other more subtle changes in habitat composition may occur due to minor alterations in surface runoff and minor changes in air quality.

The area utilized most intensively by mule deer between October 1974 and April 1975 was off-tract in Piceance Creek valley and the contiguous south-facing slopes as shown in Figure V-27. Nevertheless, deer also ranged over the entire Tract through much of the winter. Based on preliminary investigations of the Tract region, it was concluded that winter deer concentrations are generally higher in the immediate Tract vicinity than in areas a few miles from the Tract. Reduction of winter range by 2000 acres in this area will significantly diminish the Tract's carrying capacity. Without effective mitigation, that reduction may result in a reduction in the deer herd which normally winters in the Tract vicinity.

Figure V-28 illustrates the general plan for maximizing wildlife utilization of the Tract during the development, construction and operation periods. Principal elements of the plan include minimizing restriction of wildlife movement, improving carrying capacity and developing ponds on the Tract. The establishment of ponds and riparian habitat represents an approach to habitat improvement designed to maintain existing wildlife and attract new wildlife species to the Tract. Ponds and small reservoirs are sparse in the Piceance Creek basin, and the planned development of ponds on the Tract should represent a significant positive benefit to local wildlife. In addition to providing habitat for fish, fish-food organisms and other aquatic life, the ponds and riparian vegetation are expected to attract other new types of wildlife. Waterfowl can utilize ponds for feeding, nesting and shelter. The existing ponds of the area have been observed to harbor a number of waterfowl species in relatively large numbers. The creation of new, productive aquatic and riparian systems should increase waterfowl in the vicinity. Bird species which would otherwise not likely occur in the area will find suitable habitat for nesting and feeding. Birds which feed on aquatic organisms would be attracted to these productive areas. Animals such as meadow voles, raccoons and deer would benefit from the increased availability of high-quality water in this region. Ponds now are limited in number and poorly distributed. If sufficient macrophyte growth occurs, populations of semi-aquatic mammals, including muskrats, may be sustained in these ponds.

The establishment of three ponds in West Fork Stewart Gulch and three ponds in Scandard Gulch is planned. If the Scandard Gulch dam and reservoir are constructed in Phase II, the three ponds in Scandard Gulch would be relocated to other drainages on the Tract. These two valleys presently are predominately vegetated with dense sagebrush communities. Diversification of the predominant sagebrush habitat by the introduction of other habitat types will also increase diversity of wildlife in the Tract vicinity. Each pond will be formed by the construction of an earth fill dam. Each dam will be approximately 10 feet high and 200 feet long, with a 50-foot base. Excavation and clearing of existing vegetation will be required to limit nutrient input and oxygen uptake by decaying plants, and to provide a mean depth of approximately 10 feet. Each of the six dams will contain an overflow standpipe for level and flow regulation, and reservoir maintenance. This type of structure permits flexibility in the regulation of pond water level, which is critical to an efficient aquatic management program.

Each reservoir will be sealed with Type II bentonite to prevent seepage losses to ground water. Reservoirs will be filled and maintained with high quality surface or ground water. Since local ground water may not be suitable for fish or wildlife and surface water is scarce on Tract, it is anticipated that water for filling and evaporation losses will have to be supplied by importation of surface water or by treatment of local ground water.

Each of the six ponds will provide approximately five surface acres of aquatic habitat. It is anticipated that water quality sufficient for the survival and growth of rainbow trout can be maintained in these reservoirs, since rainbow trout have been observed in local ponds. Rainbow trout will be stocked initially at the rate of 400 fingerlings per acre in the spring of the first year following reservoir filling. Analysis of population growth and survival will determine the replenishment stocking rate. According to local authorities, rainbow trout growth of about one pound per year could be expected under optimum conditions. Periodic studies of fish survival and growth will be made to determine specific management plans in the future.

Habitat improvement programs will be implemented on selected undisturbed portions of the Tract. Emphasis will be on increasing the land's capability to support wintering mule deer, and thus to decrease the impact of removing 2000 acres of winter range. Such habitat improvement should also benefit other wildlife species.

The principal approach to improve suitability of the Tract for deer will involve increasing the productivity of the plant communities in the areas designated on Figure V-28. Establishment of desirable species by direct seeding will be limited to areas surrounding the newly created ponds, and to the revegetation of areas disturbed by exploration and construction activities. The specific techniques to increase the vigor and productivity of existing browse plants will not be determined until available techniques have been tested on the Tract. It is anticipated that if grazing pressure by domestic livestock continues at its present intensity, measures to improve habitat will be rendered less effective. To maximize success of the habitat enhancement program, the Lessee will attempt to reach cooperative agreements with the Bureau of Land Management on livestock grazing management during critical phases of the improvement program.

The south-facing slopes along Piceance Creek in Sections 25 and 26, T2S, R97W and Sections 31, 32 and 33, T2S, R96W, were grazed by cattle during the early winter of 1974 and appear to erode easily following grazing. This is an area inhabited by many deer during the winter when deer range is reduced and when the deer are potentially in a stressed condition. Any decrease in possible deer-cattle competition or improvement in habitat in these areas is expected to be beneficial to the deer.

(2) Erosion in Terrestrial Habitats

Site development and construction activities, including roads and pipelines, can result in erosion which affects contiguous habitats and reduces their ability to support vegetation and wildlife.

Lessee's objectives in mitigating erosion include: 1) minimization of areas to be disturbed; 2) minimization of the length of time that any area will be subject to disturbance; and 3) restoration of natural habitats on disturbed areas.

Methods of erosion control are addressed extensively in the Erosion Control and Surface Rehabilitation Plan presented in Section V. K. Control of construction procedures by inclusion of environmental provisions in construction contracts on the Tract will be standard policy.

(3) Modification of Aquatic Habitats

The destruction or modification of aquatic habitats on the Tract is expected to be negligible due to the lack of flowing waters. Habitat modification may result from site preparation, stream crossings, diversion of natural ephemeral water courses, or inundation of a natural stream by a reservoir. The disposal site for processed shale and the reservoir for mine dewatering discharges will be located in Sorghum Gulch, where natural stream flow seldom occurs.

The Lessee's objectives for minimizing damage to aquatic habitats and procedures to avoid damage are set forth in the Water Pollution Control Plan (Section V. B.) and include: 1) minimizing areas of aquatic habitats to be modified; 2) promptly correcting water contamination problems; and 3) using construction procedures to avoid siltation or direct harm to aquatic habitats. A beneficial modification of aquatic habitat will be the planned creation of six ponds as described above. Other beneficial modifications of aquatic habitat may include restriction of livestock use in areas where riparian habitat destruction may become a problem and the control of aquatic weeds by use of pond level manipulation or harvesting.

(4) Erosion and Siltation Affecting Aquatic Habitats

Erosion may result in destabilizing conditions in aquatic habitats, and increasing turbidity and siltation. Modification of vegetative cover adjacent to aquatic systems or water courses is the primary cause of increased erosion. The resulting increases in turbidity and siltation rate are generally detrimental to aquatic organisms, especially benthic macroinvertebrates and fish. High levels of turbidity can limit the productivity of algae and aquatic macrophytes, the primary producers in aquatic ecosystems. All site development and construction activities will probably contribute to this problem. Erosion control will be accomplished through the use of methods given in the Erosion Control and Surface Rehabilitation Plan (Section V. K.). The basic objectives are to: minimize erosion and siltation; and where this is unavoidable, to mitigate adverse effects on aquatic habitats.

Sedimentation ponds will be located on drainages which transport waters from construction zones in order to remove suspended solids before discharge.

Based upon observations made during the baseline investigations, ponds in the area are clear and turbidity is very low. Rapid revegetation of road banks and other disturbed areas, and the confinement of processed shale to one drainage basin which will have no discharge to Piceance Creek, should effectively minimize turbidity and siltation problems.

(5) Water Pollution Affecting Aquatic Habitats

The Stipulations regarding federal and state water quality standards prohibit discharges to any stream or tributary unless such discharges meet state and federal water quality standards. Thus, no direct water pollution from development activity is expected. Accidental discharges resulting in stream pollution are addressed in the Oil and Hazardous Materials Spill Contingency Plan presented in Section V. L.

(6) Reduction in Ground-water Discharge Affecting Terrestrial and Aquatic Habitats

Modification of terrestrial and aquatic habitats will result if a significant reduction in springs or seeps occurs. Impacts include the possible reduction in flow of a portion of Piceance Creek and reduction in water levels of ponds. Some terrestrial habitat, notably the greasewood and riparian communities, depends to some extent upon springs and seeps as a source of water. Irrigated pastures along Piceance Creek depend upon managed ground-water discharge since Piceance Creek is largely spring-fed. Consequently, changes in ground-water availability can influence distribution and composition of these communities, as well as their capacity to support wildlife.

Mine dewatering could have local and possibly more extensive, effects upon ground-water discharge. Data and information derived from the Lessee's hydrologic testing program indicate that dewatering operations can be conducted in a manner that will have little effect on springs and seeps in the vicinity of the Tract. This subject is discussed further in Section IX.B., Subsurface Hydrology. The effects of dewatering will be monitored carefully and remedial action taken if detrimental effects occur.

Such action could include sealing and grouting the mine shafts to reduce the amount of ground water entering the shafts and providing supplemental water for Piceance Creek. The flow of Piceance Creek will be maintained as necessary.

(7) Wildlife Disturbance Resulting from Human Activity

The presence of people and companion animals moving about on foot may have a greater effect upon the distribution and behavior of wildlife than the presence of buildings and vehicles. This type of wildlife disturbance will occur during all periods of development.

Several methods will be used to minimize unnecessary disturbance of wildlife because of the presence and movements of humans and their companion animals: 1) An information and education program for workers on adverse effects of extravehicular activity and wildlife harassment; 2) restriction of extravehicular activities by personnel; 3) limitation of activities in critical areas; 4) limitation or control of parking along roads controlled by the Lessee; and 5) control of pets.

(8) Effects of Air Pollution

Plant facilities will be designed to meet federal and state air quality standards, which have been promulgated to protect the public health and welfare. Air-pollution-related effects are addressed in the Air Pollution Control Plan (Section V.A.).

(9) Effects of Noise

Noise from road travel, construction and plant machinery and processing units may affect the behavior and distribution of wildlife such as deer. However, deer are known to acclimate rapidly to repetitious or familiar noises. Raptors are senstitive to loud noises, especially during the nesting period.

The objective of the Lessee is to minimize potential consequences of noise on wildlife species. Noise control plans which will serve to mitigate these potential effects are the same as those proposed for humans and are described in the Noise Pollution Control Plan (Section V.C.).

(10) Vehicle-wildlife Collisions

Unless preventive actions are taken, increased incidences of collisions between deer and vehicles will occur from increased traffic, resulting in the risk of injury or loss of human and animal life, and vehicular damage. Mass seasonal migrations of deer across highways and the daily movements of many deer between cover and foraging areas accentuate the problem in the Tract area.

The Lessee's objectives for preserving wildlife are: 1) minimization of deer mortality resulting from deer-vehicle collisions; 2) reduction of the risk of accidents causing injury to humans resulting from deer-vehicle collisions; 3) minimization of the economic costs of collision prevention systems and economic losses resulting from collisions; and 4) cooperation with regional programs for deer-vehicle collision prevention.

To accomplish these objectives, the following procedures are planned. A speed limit of 50 mph during the day and 40 mph during twilight, night and dawn will be recommended to Colorado law enforcement agencies for the Piceance Creek road in the vicinity of wintering deer concentrations. On the Tract, maximum permissible vehicle speed on secondary roads will be 25 mph.

Figure V-28 shows the system of deer barrier fences planned along both sides of the access road from the plant site to the Piceance Creek road, and along Piceance Creek road from its intersection with the Tract access road to Stewart Gulch. The fences will be built to specifications of the Colorado Department of Highways. Cattle guards will be placed at the ends of the fence and one-way gates will be incorporated in the fence design at locations depicted on Figure V-28. One-way gates allow deer which gain access to the restricted area of the highway to escape.

The intent of the recommended fencing design is to use as little fencing as necessary to achieve protection of deer and humans, while still assuring that migration and daily movements of deer and other wildlife species will not be hampered. Procedures will be followed in locating and designing fences to minimize their visibility. Principal deer movements follow north-south paths (Figure V-27). To permit such movements, underpasses will be located at appropriate positions along the Piceance Creek road deer barrier. Possible locations are shown on Figure V-28, though these might be changed after additional information on winter deer movements becomes available.

The fencing plan for Tract C-b as shown on Figure V-28 includes no drift structures. The security fencing plus the deer and rodent-proof enclosure around the water disposal basin in Sorghum Gulch will preclude deer from entry to hazardous zones. Moreover, deer tend to avoid areas of concentrated human activities. By restricting fencing to the access corridor, deer will be able to move freely over the entire Tract; therefore, a majority of the Tract's winter range will be readily accessible through most stages of development. This plan also minimizes obstruction of major migratory pathways.

(11) Management of Water Quality Control Reservoir

A dam at the base of Sorghum Gulch will provide a reservoir for water quality control. During Phase I activities, it will be used as temporary storage for water discharged from mine shafts and the development mine. During the summer months the water will be pumped through a sprinkler irrigation system in Sorghum Gulch and dissipated through evapotranspiration. The quality of this water would be acceptable for livestock and general use except for the high fluoride content (Table V-28). Fluoride levels will be monitored and if determined to be harmful to wildlife, fencing will be installed.

The Sorghum Gulch drainage will eventually receive runoff from the processed-shale pile and from the processing plant. All such water will be returned to the plant or used to moisturize processed shale. Since this water will be of poor or highly variable quality for the life of the plant, use by wildlife will be discouraged.

Based on hydrology studies and mine water inflows experienced during Phase I, it is also possible that a large dam would be built in Scandard Gulch to totally accumulate mine water discharges for a period of several years. In this case, fluoride levels in the reservoir would become higher due to the concentrating effect produced by evaporation of water from the surface. After construction of the processing plant, this water would gradually be consumed and the reservoir filled with good quality imported surface water to serve as the plant supply. During the intervening period this reservoir would also be fenced, but would eventually become usable as a wildlife resource.

(12) Secondary Effects Resulting from Growth in Human Population

It is recognized that development and operations on the Tract will contribute to the human population growth of Rio Blanco and Garfield counties, and will generate secondary influences. Secondary effects may have negative effects upon wildlife, such as the modification of wildlife habitats for housing, business and transportation, the diversion of water from current uses to commercial and industrial uses, and wildlife disturbances resulting from increased outdoor recreation. These effects will occur during all periods of development.

Table V-28 SUMMARY OF CRITICAL GROUNDWATER QUALITY

Chemical Constituent	Pump Test Data* (Concentrations in mg/1)		Limits which should not be exceeded for the indicated beneficial use (mg/1)**			
	Lower Aquifer	Upper Aquifer	Livestock	Fish	Irrigation	Drinking
Sodium	310	200	2000	85	200	10
Bicarbonate	755	570	NA***	180	NA	150
Sulfate	12	--	500	90	200	500
Fluoride	19	18	1.0	1.5	10.0	0.7–1.2
Dissolved Solids	750	560	2500	2000	700	1000

* Baseline monitoring data

** From McKee, J.E. and H.W. Wolf (editors). 1963. Water Quality Criteria (2nd edition). The Resources Agency of California. State Water Quality Control Board Publication 3–A State of California, Sacramento.

*** NA – Not Available.

The Lessee's objectives in attempting to deal with the increase in local population include formulation of a policy of cooperation with other firms, agencies, organizations and individuals to coordinate wildlife management programs throughout the region. This policy will be implemented through personnel management and planning. Methods for implementation could include the use of various media and liaison with the OSEAP, other government groups and citizens' groups.

(13) Personnel Management

Control of the effects on wildlife resulting from the activities of personnel associated with exploration, development and operations on the Tract is essentially one of managing secondary influences. These will occur during all phases of construction and operation. Some of these include hunting and fishing by personnel, the disturbance of wildlife by dogs and other domestic animals, and the disturbance of wildlife by recreation and off-road vehicles.

The proposed control strategy includes informing all construction and operating personnel of their responsibilities with respect to fish and wildlife laws, and cooperating actively with law enforcement personnel. The information program will include posting bulletins in all personnel offices, change rooms and recreation halls, and distributing relevant regulations to all employees. Wildlife conservation officers will be allowed ready access to the property. The promotion of good attitudes toward wildlife will also be fostered by supporting sports, nature and conservation groups. Current game, fish and related regulations will be posted on bulletin boards and brochures regarding these regulations will be distributed to all employees.

(14) Access Management

Continued provision for public access to the Tract to allow appropriate opportunities for harvest and non-harvest uses of wildlife resources is a requirement of Section 4(A)(4) of the Stipulations. Public access requires careful supervision because of the difficulties in maintaining adequate security and safety. The public will be allowed access to and through those parts of the Tract which are not critical to plant operation or do not pose health and safety problems. It should be noted that excessive access might adversely affect wildlife species.

Proposed policies include continuing to provide public access to the Tract at a level comparable to that during the baseline period, where such access is compatible with security and safety. Procedures for implementing these policies include fencing of critical plant-mine complex areas, the use of security guards and prohibition of firearms in areas where they would create a safety hazard. Security fences will be constructed and areas posted where firearms are not allowed.

c. Contingency Planning

Throughout this plan, reference has been made to other plans by the

Lessee, also contained in Section V, for minimizing and controlling specific types of effects on wildlife and habitat. These environmental control plans and programs include the following:

- Air Pollution Control
- Water Pollution Control
- Noise Pollution Control
- Protection of Objects of Historic or Scientific Interest and Aesthetic Values
- Fire Prevention and Control
- Health and Safety
- Overburden Management
- Processed-shale Disposal
- Disposal of Other Wastes
- Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas
- Oil and Hazardous Materials Spill Contingency Plan
- Off-tract Corridors

It must be recognized that an unforeseen accident or natural disaster could result in the loss of fish or wildlife habitat. These could include failures of air or water pollution control equipment or spills of hazardous materials. If such an event were to result in significant destruction or damage to habitat, the Lessee would attempt to restore the habitat directly affected through the use of planting, seeding, fertilizing and restocking, if necessary. These procedures would be undertaken as soon as possible after the occurrence, and would proceed in accordance with mitigating plans submitted to and approved by the AOSS. Mechanisms for reporting and responding to such unforeseen occurrences are addressed in various environmental control plans elsewhere in Section V.

5. Habitat and Wildlife Setting

a. Existing Wildlife Habitat

Sixteen categories of wildlife habitats have been defined describing what is currently known about wildlife distributions on the Tract. These are referred to as habitat types (Figure V-29), since they are recognizable units of the landscape that support a more or less distinct assemblage of wildlife species. They are not habitats in the strict sense of being the "home" of a particular species. It should be emphasized that the categorization is arbitrary and solely for the purpose of conveniently describing animal populations which continually change in time and space. Other systems may be equally valid.

(1) Streamside Vegetation

This habitat type occurs in moist zones along the margins of permanent and ephemeral streams, or near springs, seeps and ponds. Such

Figure V–29 TENTATIVE MAP OF WILDLIFE HABITAT TYPES areas have a limited and scattered distribution, and are typically vegetated by various semiaquatic sedges, rushes, grasses and herbs.

(2) Open Water

The open water of ponds and streams is important to waterfowl and other semiaquatic birds and mammals.

(3) Agricultural Meadows Below 6500 Feet

An elevation of 6500 feet was chosen as the altitude frequently observed separating many avian and mammalian species during both summer and winter. This elevation is a fair approximation of the upper limits of mule deer winter range in the valleys.

Various hay meadows and pastures occur along the flood plains of the major streams at lower elevations. Most are irrigated and productive, and are often an important component of deer winter range.

(4) Agricultural Meadows Above 6500 Feet

The agricultural meadows in the upper valleys are similar to those in the lower valleys, but greater snow cover is likely to be a major factor contributing to differential usage for many wildlife species.

(5) Lower Slopes And Bunchgrass Below 6500 Feet

The lower slopes of valleys are frequently vegetated by Indian ricegrass and scattered pinyons and junipers. The south-facing slopes are especially important to deer when the snow is deep.

(6) Lower Slopes And Bunchgrass Above 6500 Feet

Lower slopes at the higher elevations tend to support a narrower zone of bunchgrass because of continual downward encroachment by mixed mountain shrub.

(7) Bottomland Shrub and Bottomland Sagebrush Below 6500 Feet

Shrub communities, generally rabbitbrush, greasewood and big sagebrush, typically occur at the base of the lower slopes. Occasionally these shrub communites extend out onto the valley floors.

(8) Bottomland Shrub and Bottomland Sagebrush Above 6500 Feet

Perhaps the most conspicuous differences between the lower and upper valley areas are the extensive and very homogeneous stands of big sagebrush which frequently replace agricultural meadows on the floors of the upper valleys. Greasewood is absent at these higher elevations, although rabbitbrush is occasionally present.

(9) Lateral Draws

Small draws that cut perpendicularly into larger valleys are common topographic features, especially at lower elevations. They are characterized by a steep, intermittent drainage channel that dissects the bedrock at the beginning of the draw and forms a steep-sided channel through the alluvium at the bottom. The usual vegetational pattern is dense, big sagebrush covering a small alluvial fan; mixed mountain shrub on northern exposures (bitterbrush, mountain mahogany, serviceberry, and occasionally oak); and bunchgrass with scattered pinyons and junipers on the southern exposures. Outcrops of sandstone (rimrock) often occur as well. These draws have a particular significance to deer, providing both food and shelter during extreme winter weather.

(10) Pinyon-juniper Woodland

Pinyon-juniper woodlands occur over wide areas. Understory vegetation varies considerably, with some stands having dense shrubs or grasses and others being more open or sparsely vegetated. The common understory shrubs include big sagebrush, mountain mahogany, bitterbrush, snowberry and serviceberry.

(11) Rimrock

Most of the sandstone cliffs and ledges occur in close proximity to pinyon-juniper woodlands. These areas provide important denning and nesting areas for mammals and birds.

(12) Burned Areas

Old burns occasionally occur within the pinyon-juniper woodlands. The clearings that result are usually characterized by widely-spaced dead trees and a ground cover in which Indian ricegrass is dominant.

(13) Chained Pinyon-juniper Rangeland

The chaining program of the Bureau of Land Management has created large blocks of open areas within the pinyon-juniper woodland. These areas are distinctive, consisting of fallen trees with shrubs and grasses characteristic of the understory of pinyon-juniper woodlands.

(14) Upland Sagebrush

Big sagebrush is a dominant plant species at many sites, both on ridges and in valley bottoms. As used here, upland sagebrush refers to the extensive stands of big sagebrush that occur as clearings within or near pinyon-juniper woodland.

(15) Mixed Mountain Shrubland

Higher elevations are sometimes dominated by shrubby species including big sagebrush, mountain mahogany, serviceberry and bitterbrush. Small stands of mixed mountain shrub also occur at lower elevations on the north slopes of the lateral draws.

(16) Douglas-fir Forests

Isolated stands of Douglas-fir occur on the Tract, but to a very limited extent. These stands are represented in some cases by less than a dozen trees. At the higher elevations outside the Tract boundary, Douglas-fir forests commonly occur on the cooler north-facing slopes.

b. Animal Relationships

(1) Mule Deer

Mule deer are abundant in the general vicinity of the Tract. The deer in this locality live principally at higher elevations during summer, but from fall through spring large numbers remain close to the Tract itself. The Tract should be considered part of the total winter range for the deer of the Piceance Creek basin. It is not a significant component of summer range even though a few deer may be seen on the Tract during the hottest months. Migrational movements are discussed below.

During an eight-month period from September 1974 through mid-May 1975, approximately 500 to 1000 deer existed in and about the Tract study area (the Tract plus one mile of surrounding area). During this period, six habitat types were heavily utilized by the deer: 1) the pinyon-juniper woodlands; 2) chained areas; 3) upland sagebrush communities; 4) lower agricultural meadows; 5) lower, south-facing slopes; and 6) the mixed mountain shrub communities of the small lateral draws. All these habitat types contain one or more plant species important to the survival of deer through the winter. Browse studies conducted on the Tract indicate that big sagebrush, mountain mahogany, antelope bitterbrush, serviceberry and rabbitbrush are important shrub browse species, though certain native herbs and grasses and several agricultural species (notably alfalfa) are also important as deer browse.

Pinyon-juniper woodlands provide forage for deer and provide cover and protection from wind. Upland sagebrush and chained areas also are important as feeding areas; and, on fresh snow, it is common to see deer tracks leading from bedding grounds within the woodlands out into these adjacent open areas.

Agricultural meadows in the lower valleys are particularly attractive to deer during the fall and spring. In the fall of 1974, following the September-October migratory influx, the meadows between Sorghum Gulch and the P-L ranch road contained many deer. In the spring of

1975, large concentrations of deer again were counted in the lower valleys, although they tended to be downstream several miles. Two hundred and eight deer, for example, were counted during May within a one-mile inverval along the road at the Willow/Piceance Creek junction.

Although the 1974-1975 winter season was comparatively mild, snow covered most of the Tract area for several weeks during late February. This was probably the most physiologically stressful period for the deer, since snow became crusted and not only covered the forage but hampered movements as well. The south-facing slopes of the lower valleys and the mixed mountain shrub of the small lateral draws were the areas most heavily used during this period. Snow melts sooner on these lower, south-facing slopes than other areas, and consequently deer are provided with food as well as warmth during times of extreme cold. Furthermore, these same south-facing slopes become important in early spring since it is here that the earliest spring growth occurs.

(2) Other Large Mammals

Elk rarely occur on the Tract and are not numerous in nearby areas. Some of the ridges to the east of the Tract supported a few individual elk for an unknown length of time during the 1974-1975 winter season. At higher elevations to the south of the Tract elk droppings are fairly common on certain hillsides and small groups of elk are occasionally seen. Feral horses, although common in the western portion of the Piceance Creek basin, have not been seen on or close to the Tract.

(3) Small Game

The desert cottontail is the only small game mammal that has been identified in the area. Numbers have been low for several years, according to local residents, but during some years relatively high densities occur. The cyclic nature of their populations and their importance as prey species is discussed below. The cottontails on the Tract occur in most habitats, although predominantly in valley sagebrush, pinyon-juniper and chained areas.

Mourning doves are the most common game bird on the Tract. They are most numerous in the lower valleys. Open water is an important component of their habitat, and stock watering tanks and ponds in the valley sagebrush habitat type attract large flocks, especially during the dry, late summer period.

Blue grouse, sage grouse and chukar are game birds which occasionally live near the Tract. Blue grouse habitat is typically mixed coniferous-aspen forest with adjacent open areas; also utilized are mixed mountain shrub habitats. Sightings have only occurred at higher elevations south of the Tract. Sage grouse depend heavily on sagebrush for food. Evidence of sage grouse (droppings) is occasionally found inside the one-mile study area boundary on the south side of the Tract, but no evidence or sightings have been reported within the Tract itself.

Chukar were released in the general region by the Colorado Division of Wildlife, but the pattern of sightings has been too limited to determine actual distribution, abundance or habitat preferences in the area. No chukar have been observed on the Tract.

Waterfowl are not abundant in the area because of the limited amount of open water. Mallards, cinnamon teal, green-winged teal and blue-winged teal are the most commonly observed species in summer. During winter, common goldeneye, bufflehead, gadwall, American widgeon and red-breasted merganser are also found, particularly on the larger ponds in the vicinity of the Tract.

(4) Fish

Brook trout are the most common game fish found in Piceance Creek and in the lower sections of the major tributaries near the Tract. The population is not large, and the creek's present value to sport fishing is minor. Apparently some reproduction of brook trout occurs in Stewart, Piceance and Willow Creeks and in lower Stewart Lake. Rainbow trout occur in some of the ponds within the area, and a few occur in Piceance Creek, but their present recreational value is low.

Mountain suckers and speckled dace are the most common non-game fish found in Piceance Creek and the major tributaries near the Tract. The mountain sucker is the most abundant fish species in Piceance Creek. These species are forage fish. They spawn in the streams in the Tract vicinity.

(5) Non-Game Animals

Non-game animals in this discussion refer to those species for which hunting licenses are not specifically sold.

A great many species of non-game animals have been documented as living on the Tract. At the end of one year of baseline study, 24 species of non-game mammals, 106 species of non-game birds and 6 species of non-game reptiles and amphibians have been positively identified. In the following discussion some of the interesting species will be discussed individually, but because there are so many species, the remainder will be considered in terms of species groups.

Some of the most abundant as well conspicuous mammals that occur on the Tract are ground squirrels and chipmunks. The golden-mantled ground squirrel is very common. During most of the summer it can be seen throughout the Tract, from the lower valleys to the Piceance/Parachute Creek divide. Three species of chipmunks occur, the Colorado, least and Uinta chipmunks. A small colony of Richardson's ground squirrels lives at the lower end of Sorghum Gulch, but none have been seen elsewhere on the Tract.

Species of small rodents are also common on the Tract. Although they are rarely seen, they are very important herbivores and are prey species for carnivores and raptors. Their local distributions and importance within the total food web will be discussed below.

Pocket gophers are not numerous on the Tract, but their diggings are conspicuous, especially in the valley sagebrush and occasionally in the chained and pinyon-juniper habitats. In aspen groves at higher elevations diggings are sometimes extensive. This is the same species of pocket gopher that occurs up to timberline throughout Colorado.

A number of predatory mammals occasionally inhabit the Tract, although they are rarely seen. Coyotes are numerous on the Tract compared to elsewhere in Colorado. This judgment is based on comparing results of standard (U.S. Fish and Wild Life Service) scent-post surveys near the Tract with those performed elsewhere. Signs of bobcats are commonly found, especially along the rimrocks of the gulches. Raccoons, striped skunks, badgers, and two species of weasels (the ermine and long-tailed weasel) are uncommon, but widely distributed.

Muskrats are common in Piceance Creek as well as in nearby ponds and irrigation ditches. Beaver have been observed also, but no permanent dams occur in the area. Porcupines, yellow-bellied marmots and white-tailed jackrabbits are uncommon. The red squirrel is rare on the Tract since there are limited stands of Douglas-fir. No bats have been encountered so far.

The diversity of birds on the Tract is impressive considering the generally dry environment and limited riparian and aquatic areas. Passerines and other small birds (excluding game birds, raptors and waterfowl) have been identified during the first year of study. These birds occur in all habitats.

The diversity of raptorial birds is particularly noteworthy. The migratory patterns of the common species are discussed later. The red-tailed hawk, American kestrel (sparrow hawk), rough-legged hawk and great horned owl are the most numerous of those identified. One sighting of the prairie falcon (classified as a threatened species) was documented during February 1975. Both the golden eagle and the bald eagle are seen on-tract part of the year. The golden eagle is often seen during summer at the southern higher elevations beyond the Tract. A pair of golden eagles nested on the Tract during 1975. The bald eagle is an uncommon winter resident. Both the bald eagle and golden eagle are seen among the pinyon-juniper and rimrock, and both species are important scavengers of mule deer.

The species diversity of reptiles and amphibians on the Tract is not large. The sagebrush lizard, northern plateau lizard, desert short-horned lizard and wandering garter snake are common. These four species of reptiles can be found in most habitats on the Tract. The gopher snake is rarely seen, and only one species of amphibians (the leopard frog) has been identified in the riparian and aquatic habitat types.

(6) Endangered or Threatened Species

It is possible that the two subspecies of the endangered peregrine falcon (*Falco Peregrinus* var. *Falco Peregrinus* var. *tundrius*) occasionally inhabit the area, but no sightings have been documented to date. The nationally threatened prairie falcon (*Falco mexicanus*) has been sighted once near the Tract. None of these three species of falcons is believed to nest inside the Tract boundaries. The greater sandhill crane (state endangered) has been observed in the Tract vicinity during migration, but none has been seen during the breeding period. The spotted bat (threatened), the black-footed ferret, Colorado squawfish, humpback chub and pharanagat bonytail (all nationally endangered), and the gray wolf, river otter and wolverine (state endangered), are species of the general region, but none has been reported in the near vicinity of the Tract. More significantly, the Tract is not good potential habitat for any of these species and could only be considered fair habitat for the prairie falcon and American peregrine falcon.

(7) Other Wildlife of Uncertain Occurrence

Mountain lions have not been reported on the Tract by field personnel or local residents. However, they do occur in the vicinity. The nearest recorded sighting was in West Fork Parachute Creek approximately 14 miles to the south of the Tract. Black bears have been seen by ranchers at higher elevations, but no sightings have been reported on the Tract. Feral horses occur to the west, but their movements do not bring them close to the Tract. It is possible that one or more species of foxes (red, gray or kit fox) could occur on the Tract, but none has been sighted to date. The ringtail possibly occurs on the Tract, but there are no records of sightings or trappings in the immediate area. Snowshoe hare, black-tailed jackrabbit and mountain cottontail could occur on or near the Tract, but no identifications have been made. The western rattlesnake and collared lizard are reptiles that are known to be nearby in Parachute Creek, but none has been identified near or on the Tract.

c. The Food Web

The pathways of energy transfer through the local food web are understood only in a general way. Though better quantification will become available later, the major relationships may be characterized qualitatively at this time (Figure V-30). Such information is particularly relevant to the Fish and Wildlife Management Plan, since it singles out the more important plant communities which might subsequently be protected or reestablished through revegetation programs. In this respect, food web considerations take on the same management perspective as do considerations of migrational patterns discussed below. Both are concerned with dynamic biological interrelationships, but are viewed in terms of more or less static vegetational and topographic units.

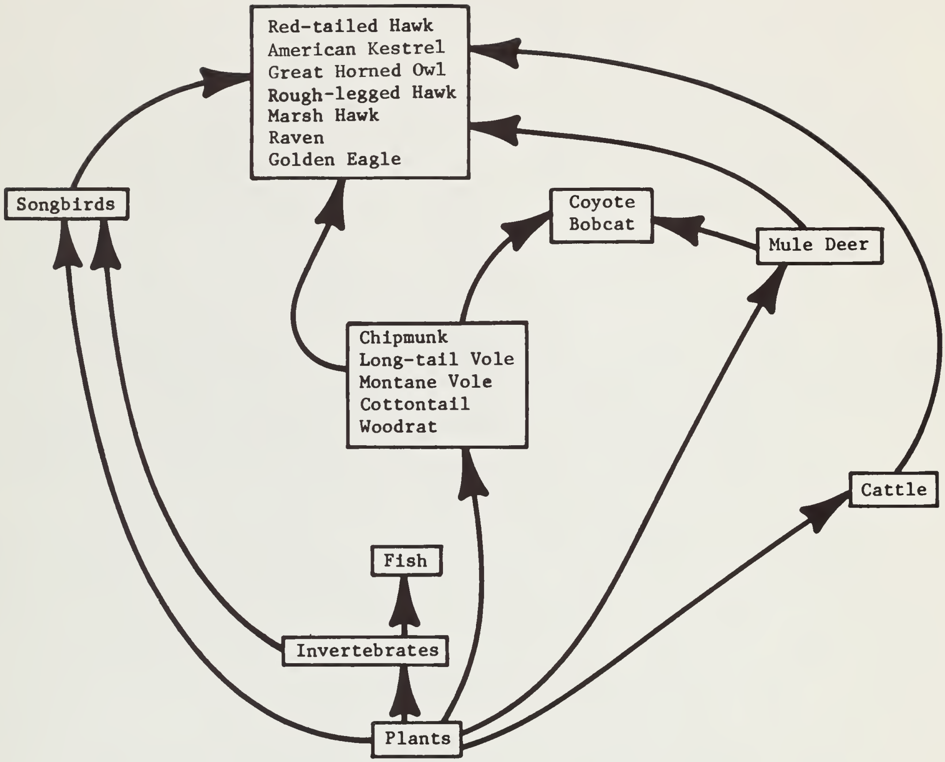


Figure V—30 MAJOR FOOD WEB RELATIONSHIPS

The major prey of most of the larger mammalian and avian predators in the vicinity of the Tract includes two species of voles (montane vole and long-tailed vole), one species of cottontail rabbit (the desert cottontail), and mule deer (principally as carrion). Other prey species of importance include deer mice, bushy-tailed woodrats, pocket gophers, chipmunks and ground squirrels of several species, small birds and insects.

The montane vole occurs mainly in moist agricultural meadows; in drier upland areas it is largely replaced by the long-tailed vole. These two species of "meadow mice" constitute an enormously important food base for both migratory and resident predators of the Tract area. Both species are to some extent cyclic, although in most years populations are likely to be fairly large with peak densities usually reached during mid to late summer.

The significance of the desert cottontail as a food base for predators is similar to that of the voles, and populations of this species also fluctuate widely. According to local residents, cottontail populations have been low in this general area for several years but are now increasing. Data gathered on the Tract so far is insufficient for verification of such trends. The desert cottontail is widely distributed on the Tract and although it can be found in most habitat types, it is typically most numerous in the pinyon-juniper woodlands, chained areas and valley sagebrush communities.

Mule deer are an important source of carrion for many of the predators which occur in the Tract area which at times are scavengers. Such animals include coyotes, golden eagles and occasionally bobcats. The more common scavengers (which typically do not kill prey) include magpies, ravens and turkey vultures. Deer mortality studies have shown that most winter deer deaths occur in the small lateral draws of the major drainages and in the lower valleys adjacent to the agricultural meadows. Such areas are utilized by most of these scavenging animals during winter. To what extent deer fawns or adult deer are actually killed by predators is not known. Coyotes, however, are known to have killed some deer on the Tract during the fall-spring period of 1974-1975.

d. Migratory Patterns of Mule Deer

There is confusion regarding the definition of migratory deer in the Piceance Creek basin. On one hand, deer commonly migrate in mountainous areas, from higher summer range to lower winter range. On the other hand, the migratory deer herd of the Piceance Creek basin is famous because of impressive movements over longer distances. These have been reported in past years. Accounts vary, but massive movements are supposed to have occurred in an east-west direction to and from a summer range located 20 to 60 miles away from the Tract.

It is difficult to determine where deer go on a year-round basis and to sort out their summer movements when they disperse widely throughout remote terrain. The deer studies conducted for the Tract have provided information concerning diurnal deer movements and information concerning major fall-spring movements within the Tract study area. While no studies have been undertaken by Tract personnel to determine the distances these wintering deer may go during summer, there is no suggestion from several related deer studies that their observed movements represent any kind of unusual behavior. For this reason, and until there is evidence to the contrary, it seems justified to use such phrases as migratory routes, migrational pathways, etc., to indicate the ordinary and typical movements of deer to and from nearby summer range, and not to consider the deer in the Tract area as being exceptional in this regard.

Some ridges on the Tract seem to be used by deer somewhat more heavily than others during the fall-spring period. Those ridges most heavily used, as indicated by a study performed during October 1975, are located: along Little Scandard Gulch; east of Sorghum Gulch; and east of Middle Fork Stewart Gulch. These are long and continuous ridges extending approximately 10 to 12 miles to the south to the Piceance/Parachute Creek and Piceance/Roan Creek divides. Other adjacent ridges are similar, but some topographic and vegetational differences occur.

The higher elevations to the south of the Tract are believed to be the main summer range for most of the deer that winter on the Tract. The lower limit of summer range can be described as a gradient, ending approximately at the upper limit of the pinyon-juniper woodland.

e. Migratory Patterns of Raptors

During early spring there are relatively few raptorial birds in the Tract area. The nesting species that occur include great-horned owls, red-tailed hawks, kestrels, golden eagles, Cooper's hawks and marsh hawks. As the season progresses more red-tailed hawks and kestrels can be seen; these two species become the most numerous raptors throughout summer. Marsh hawks are occasionally seen during summer, and they become more common during early fall. Rough-legged hawks only become abundant during the fall, but they remain throughout the winter months. In 1974-1975 they were the most numerous wintering raptors. Great-horned owls are common on the Tract year-round.

During the fall periods when raptor diversity is highest, habitats utilized by these birds tend to differ, although considerable overlap in their respective hunting areas occurs. The lower valleys are of singular importance, since this habitat is utilized most heavily by all species. Frequently red-tailed hawks, rough-legged hawks, marsh hawks and kestrels can be seen sharing the same meadow and preying almost exclusively on montane voles. The differential habitat usage area among these birds is sometimes very subtle. The rough-legged hawk, for example, restricts its hunting almost entirely to the lower valleys, and inhabits the area only during the colder months of the year. The red-tailed hawk tends to utilize a wider range of habitat types, including the denser areas of pinyon-juniper woodland, rimrock and shrubby draws, where it commonly feeds on the desert cottontail. Kestrels feed more commonly on grasshoppers when the insects are numerous, but they also share populations of montane voles and long-tailed voles with other raptors when rodents are at high densities. Differences in habitat segregation and in the timing of migratory movements tend to reduce competition for similar food sources. Although these behavioral differences may not be obvious among the raptors found in the Tract area, they are nevertheless important in sustaining these predatory birds, which have a relatively insecure position at the very ends of the local food chains.

f. Importance of Species

The matrix shown in Table V-27 lists the wildlife found on the Tract and ranks selected species according to their relative importance. Since all species do not have the same aesthetic, economic or ecological value to all individuals, the judgments reflected in this matrix, although based on data collected during our field investigations, are of a subjective nature.

6. Operational Setting

Figure I-7 indicates the proposed sites of disturbance from the Tract operational plan. Figure I-6 sets forth the schedules of activity from mine development to post development and indicates areas of consequence and the type of effects. These materials have been taken from Section I of the DDP, where more detail may be found. Tables V-29, V-30 and V-31 indicate specific impacts which might be expected to occur during each phase as the result of scheduled activities.

Comparison of Figure V-29 (habitat types) and Figure I-7 (development plot plans) enables an estimate to be made of the general types of habitat to be directly disturbed.

Table V–29 MAJOR POTENTIAL RELATIONSHIPS BETWEEN PLANNED ON-TRACT ACTIVITIES AND WILDLIFE MANAGEMENT PROBLEM AREAS, PHASE I

PLANNED ON-TRACT ACTIVITIES / WILDLIFE MANAGEMENT PROBLEM AREAS	PHASE I – MINE DEVELOPMENT					
	Site preparation and construction: mine surface facilities, conveying/stockpiling, generators, water catchment dams, and water storage facilities	Shaft sinking	Construction of roads, powerlines, communication lines, and water pipeline	Development and operation of water disposal system	Conveying and stockpiling	Increase in population
a. Modification of terrestrial habitats	Habitat destruction in site preparation area (see Table V–32 for estimate of acreages of major vegetation types modified)	(Included in area disturbed in site preparation and construction)	Habitat disturbance in a variety of habitats, by vegetative cover destruction and soil disturbance	Habitat destruction at reservoir site (see Table V–32 for acreages of major vegetation types affected)	(Included in area disturbed in site preparation and construction)	N/A
b. Erosion in terrestrial habitats	Exposure of soils in construction area due to site disturbance by bulldozing, plant cover removal, cut and fill	Materials exposed at any disposal sites	Exposure of soils along rights-of-way prior to revegetation	Exposure of soils in embankment areas	Materials exposed in stockpile	N/A
c. Modification of aquatic habitats	N/A	N/A	Bridges and locations where pipelines cross streams will modify aquatic habitat	Reservoir to disrupt intermittent stream	N/A	N/A
d. Erosion and siltation affecting aquatic habitats	Erosion in terrestrial habitat areas	Erosion in terrestrial habitat areas	Erosion in terrestrial habitat areas Localized siltation at bridges and stream crossings	Siltation due to erosion resulting from construction activity	Erosion in terrestrial habitat areas	N/A
e. Water pollution affecting aquatic habitats	Machinery accidents Oil spills	Machinery accidents Oil spills	Machinery accidents Oil spills	Reservoir leakage or overflow	Machinery accidents	Sanitary wastes
f. Reduction in ground water discharge affecting terrestrial and aquatic habitats	N/A	Dewatering during shaft sinking	N/A	N/A	N/A	N/A
g. Wildlife disturbance resulting from human activity	Increased localized activity	Increased localized activity	Disturbance impinging on many habitats Interference with animal movement patterns	Increased localized activity	Increased localized activity	Increased human activity Increased traffic Possible poaching Disturbance by pets
h. Effects of air pollution	Fugitive dust Generator emissions Vehicle emissions	Fugitive dust Generator emissions Vehicle emissions	Fugitive dust Vehicle emissions	Fugitive dust Vehicle emissions	Fugitive dust	Vehicle emissions
i. Effects of noise	Heavy machinery Blasting General construction activities	Heavy machinery Drilling Blasting	Heavy machinery Blasting General construction activities	Heavy machinery Other construction activity Well drilling	Equipment operation	Increase in traffic
j. Vehicle-wildlife collisions	N/A	N/A	Intersection with animal movement areas	N/A	Intersection with animal movement areas	Increase in traffic
k. Management of water quality control reservoir	N/A	High-fluoride water production and transportation	N/A	High-fluoride water storage	N/A	N/A
l. Secondary impacts from growth in human population	N/A	N/A	N/A	N/A	N/A	(See Figure II–3 for manpower estimate in Phase I)
m. Personnel management	N/A	N/A	N/A	N/A	N/A	Temporary nature of population leading to ongoing education needs
n. Access management	N/A	N/A	N/A	N/A	N/A	Regulation of public access in areas of construction activities

N/A – Not applicable

Table V - 30 MAJOR POTENTIAL RELATIONSHIPS BETWEEN PLANNED ON-TRACT ACTIVITIES AND WILDLIFE MANAGEMENT PROBLEM AREAS, PHASE II

PLANNED ON-TRACT ACTIVITIES / WILDLIFE MANAGEMENT PROBLEM AREAS	PHASE II – PLANT CONSTRUCTION				
	Site preparation and construction: mine and plant facilities, material handling facilities, power system, water catchment dams, auxiliary facilities, ventilation shafts	Construction of roads and pipelines	Operation of water disposal system	Conveying and stockpiling	Increase in population
a. Modification of terrestrial habitats	Habitat destruction in site preparation area (see Table V–32 for estimate of acreages of major vegetation types modified)	Habitat disturbance in a variety of habitats, by vegetative cover destruction and soil disturbance	(Included in area disturbed in development of water disposal system, Phase I, Table V–29)	(Included in area disturbed in site preparation and construction)	N/A
b. Erosion in terrestrial habitats	Exposure of soils in construction area due to site disturbance by bulldozing, plant cover removal, cut and fill	Exposure of soils along rights-of-way prior to revegetation	N/A	Materials exposed in stockpile	N/A
c. Modification of aquatic habitats	N/A	Bridges and locations where pipelines cross streams will modify aquatic habitat	Reservoir to disrupt intermittent stream	N/A	N/A
d. Erosion and siltation affecting aquatic habitats	Erosion in terrestrial habitat areas	Erosion in terrestrial habitat areas Localized siltation at bridges and stream crossings	N/A	Erosion in terrestrial habitat areas	N/A
e. Water pollution affecting aquatic habitats	Machinery accidents Oil spills	Machinery accidents Oil spills	Reservoir leakage or overflow	Machinery accidents	Sanitary wastes
f. Reduction in ground water discharge affecting terrestrial and aquatic habitats	N/A	N/A	N/A	N/A	N/A
g. Wildlife disturbance resulting from human activity	Increased localized activity	Disturbance impinging on many habitats Interference with animal movement patterns	Localized activity	Increased localized activity	Increased human activity Increased traffic Possible poaching Disturbance by pets
h. Effects of air pollution	Fugitive dust Generator emissions Vehicle emissions	Fugitive dust Vehicle emissions	N/A	Fugitive dust	Vehicle emissions
i. Effects of noise	Heavy machinery Blasting General construction activities	Heavy machinery Blasting General construction activities	N/A	Equipment operation	Increase in traffic
j. Vehicle-wildlife collisions	N/A	Intersection with animal movement areas	N/A	Intersection with animal movement areas	Increase in traffic
k. Management of water quality control reservoir	N/A	N/A	High-fluoride water storage	N/A	N/A
l. Secondary impacts from growth in human population	N/A	N/A	N/A	N/A	(See Figure III–3 for manpower estimate in Phase II)
m. Personnel management	N/A	N/A	N/A	N/A	Temporary nature of population leading to ongoing educational needs
n. Access management	N/A	N/A	N/A	N/A	Regulation of public access in areas of construction activities

N/A – Not applicable

Table V–31 MAJOR POTENTIAL RELATIONSHIPS BETWEEN PLANNED ON-TRACT ACTIVITIES AND WILDLIFE MANAGEMENT PROBLEM AREAS, PHASE III

PLANNED ON-TRACT ACTIVITIES / WILDLIFE MANAGEMENT PROBLEM AREAS	PHASE III – PLANT OPERATIONS							
	Commercial mining	Mine dewatering	Water treatment	Crushing, conveying, and stockpiling	Retorting and upgrading	Processed shale disposal	Operation of water catchment dams	Increase in population
a. Modification of terrestrial habitats	(Included in area disturbed in site preparation and construction, Phase I, Table V–29)	N/A	Habitat destruction in area of reservoir defluoridation plant, or other facilities (see Table V–32 for acreages of major vegetation types affected)	(Included in area disturbed in site preparation and construction, Phase I, Table V–29)	(Included in area disturbed in site preparation and construction, Phase II, Table V–30)	Habitat destruction in Sorghum Gulch area (see Table V–32 for acreages of major vegetation types affected)	N/A	N/A
b. Erosion in terrestrial habitats	N/A	N/A	N/A	Materials exposed in stockpile	N/A	Exposure of processed shale prior to revegetation	N/A	N/A
c. Modification of aquatic habitats	N/A	N/A	Reservoir to disrupt intermittent stream	N/A	N/A	Shale pile to disrupt intermittent stream	Possible disruption of intermittent streams	N/A
d. Erosion and siltation affecting aquatic habitats	N/A	N/A	N/A	Erosion in terrestrial habitat areas	N/A	Erosion in terrestrial habitat areas	N/A	N/A
e. Water pollution affecting aquatic habitats	Machinery accidents Oil spills	Spillage of water being transported to reservoir	Reservoir leakage or overflow Defluoridation plant supplies spills	Machinery accidents	Machinery accidents Oil spills Other products or supplies spills	N/A	Water catchment dam leakage or overflow	N/A
f. Reduction in ground water discharge affecting terrestrial and aquatic habitats	N/A	Dewatering of mining zone	N/A	N/A	N/A	N/A	N/A	N/A
g. Wildlife disturbance resulting from human activity	Localized activity	Localized activity	Localized activity	Localized activity	Localized activity	Localized activity	Localized activity	Increased human activity Increased traffic Possible poaching Disturbance by pets
h. Effects of air pollution	Fugitive dust Equipment emissions	N/A	N/A	Fugitive dust Equipment emissions	Equipment emissions Plant emissions Steam vents Cooling towers	Fugitive dust	N/A	Vehicle emissions
i. Effects of noise	Equipment operation Hoisting and dumping of shale	Equipment operation	Defluoridation plant equipment	Equipment operation	Heavy machinery and plant equipment	Operation of disposal equipment	N/A	Increase in traffic
j. Vehicle-wildlife collisions	N/A	N/A	N/A	Intersection with animal movement areas	N/A	N/A	N/A	Increase in traffic
k. Management of water quality control reservoir	N/A	High-fluoride water production and transportation	High-fluoride water storage	N/A	N/A	N/A	N/A	N/A
l. Secondary impacts from growth in human population	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(See Table IV–2 for manpower estimate in Phase III)
m. Personnel management	N/A	N/A	N/A	N/A	N/A	N/A	N/A	More permanent nature of work leads to better education of workers and their families
n. Access management	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Regulation of public access in areas of plant operation and mining activities

N/A – Not applicable

Erosion Control

V. K. Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas

1. Summary of Activities Affecting Erosion Control and Surface Rehabilitation

2. Summary of Lease Requirements, Applicable Law and Regulations

3. Erosion Control Plan

   a. Activities Covered in the Erosion Control Plan

      (1) Planning Activities
      (2) Design Activities
      (3) Construction and Operational Activities

   b. Erosion Control Methods and Application

      (1) Surface Erosion Control

         (a) Cuts and Fills
         (b) Runoff Control
         (c) Temporary Slope Protection
         (d) Limiting Exposed Surfaces
         (e) Wind Erosion Control

      (2) Stream Flow Control

         (a) Sedimentation
         (b) Flow Concentration
         (c) Energy Dissipation
         (d) Stream Crossings
         (e) Channel Modifications

4. Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation

   a. Introduction

   b. Revegetation of Disturbed Areas Other Than Processed Shale

      (1) Timing

      (2) Techniques and Materials

(a) Seed Selection
(b) Fertilizer
(c) Mulch Selection
(d) Seedbed Preparation
(e) Seeding and Mulching Operations
(f) Planting Time
(g) Invasions
(h) Fertility Testing
(i) Use of Existing Vegetation
(j) Evaluation and Followup
(k) Alternatives to Revegetation

c. Revegetation of the Processed-shale Disposal Pile

K. Erosion Control and Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation of Disturbed Areas

The development of the Tract will result in the disturbance of approximately 1500 to 2000 acres of vegetation, soil and rock. This plan discusses the areas which will be disturbed; reviews the applicable Lease terms for controlling these activities; and details the Lessee's plan to comply with the Lease terms and other applicable regulations. Included as an integral part of this plan are a program for surface rehabilitation, and a discussion of the work which demonstrates the technology for revegetation of disturbed areas.

In addition to the plan described here, the Lessee has prepared other plans which discuss certain aspects of erosion control and surface rehabilitation. The plans are:

- Water Pollution Control (Section V. B.)
- Overburden Management (Section V. G.)
- Processed-shale Disposal (Section V. H.)
- Oil and Hazardous Materials Spill Contingency Plan (Section V. L.)

1. Summary of Activities Affecting Erosion Control and Surface Rehabilitation

Over the life of the project approximately 1500 to 2000 acres of vegetated land will be disturbed. Phase I activities, which include development of the mine surface facilities, coarse-ore conveyor and stockpile, construction water wells, a dam and reservoir in Sorghum Gulch, and the main access road and roads to these facilities, will disturb approximately 155 to 220 acres. The distribution of the various vegetative types that would be affected by these construction activities is shown in Table V-32.

During Phases II and III, the principal land surface disturbance will be the development of the plant site, auxiliary buildings, a dam and reservoir in Scandard Gulch and the processed-shale pile, as well as other ancillary facilities. These disturbances total about 1400 to 1810 acres. Distribution of the various vegetative types that would be affected by these developments are also summarized on Table V-32.

2. Summary of Lease Requirements, Applicable Laws and Regulations

Section 11 of the Stipulations provides requirements for rehabilitating and stabilizing disturbed lands. Section 11 (B) of the Stipulations requires that the Lessee submit an Erosion Control and Surface

Table V–32 SUMMARY OF VEGETATION REMOVED BY DEVELOPMENT OF THE TRACT

Activity	Vegetation Type: Sage-brush	Chained Pinyon-Juniper	Pinyon-Juniper	Douglas-Fir	Annual Weed	Total Acreage (by activity)
PHASE I						
Mine Surface Facilities	5	15-25			5	25-35
Coarse Ore Conveyor	0-5	5				5-10
Coarse Ore Stockpile (Initial)	10	25-30				35-40
Road Construction (New)						
-Primary Tract Access	10-15	30-35				40-50
-Dam Access	5	5-10				10-15
-Primary Coarse Ore Conveying/Stockpiling	0-5	5				5-10
Dam Sites (Sorghum & Cottonwood Gulches)	0-5		15	0-5		15-25
Construction Water	0-5	5				5-10
Reservoir (Sorghum Gulch)	0-5		15	0-5		15-25
PHASE II						
Truck Maintenance Facility	5	5-10				10-15
Plant Site	40-60	100-120	5-10		5-10	150-200
Processed Shale Handling System	5	10-15				15-20
Power R-O-W	0-5	5-10				5-20
Pipeline Corridor R-O-W	5	5-15				10-20
Road Construction (New)						
-Ventilation Housing Access	5		10-15			15-20
-Secondary Coarse Ore Stockpile		2-5				2-5
-Water Catchment Dam	5	5-10				10-15
Auxiliary Buildings	8-10	15-20	5			28-35
Coarse Ore Stockpile (Temporary)	15-20	25-35				40-55
Dam Site (Scandard Gulch)*	15-25				10-15	25-40
Reservoir (Scandard Gulch)*	70-13		20-40			90-170
PHASE III						
Processed Shale Pile	190-225	395-470	405-490		10-15	1000-1200
Total Acreage (by type)	393-560	657-825	475-590	0-10	30-45	1555-2030

*Dam and reservoir constructed only if additional mine dewatering storage is needed.

Rehabilitation Plan as part of any exploration or development plan. Sections 11 (C) and (J) of the Stipulations also require the Lessee to ultimately leave all disturbed areas in stabilized, revegetated condition consistent with environmental conditions at the time baseline data were gathered. In addition, Section 11 (L) (3) of the Stipulations requires that the Lessee demonstrate at the time of submission of the DDP that revegetation technology is available to enable reestablishment of permanent vegetation of a quality to support fauna in the same kinds and same numbers as existed at the time the baseline data was obtained. This plan is intended to meet all of these requirements.

This plan addresses all methods of erosion control which may be utilized in connection with the Tract development, including construction procedures, operating procedures and revegetation of disturbed areas. It is divided into a section dealing with all aspects of erosion control other than revegetation, and another section on surface rehabilitation and demonstration of revegetation technology. In addition to this plan, many aspects of the planned development activity which have significant erosion control features are discussed elsewhere in the DDP.

3. Erosion Control Plan

The primary goals of erosion control are to stabilize soil, minimize siltation and control dust. In addition, erosion control planning affects other goals such as maximizing land productivity, providing an aesthetically pleasing environment, avoiding health and safety hazards, and maintaining wildlife habitat. All of these factors must be considered in making decisions relating to erosion control. In some cases, these considerations may complement one another; in others they may conflict. In conducting operations on the Tract, the Lessee will follow concepts set forth in this plan.

a. Activities Covered in the Erosion Control Plan

(1) Planning Activities

Erosion control planning is, and will continue to be, included as a part of all operational planning activities. Although substantial planning for the project has already taken place, the planning process is continuous. Actual experience, policy changes by regulating agencies, modifications to plans and other events require constant revision and updating of planning activities. In general, planning requires discussion, coordination and cooperation with many entities. In particular, the Lessee will continue to coordinate activities with and through the AOSS to the Bureau of Land Management and the OSEAP, technical personnel within the Lessee's organization, consultants and contractors, state and local agencies and public interest groups, including conservation oriented organizations.

(2) Design Activities

This plan establishes and adopts basic plans, concepts, and standards for erosion control. As detailed designs of facilities and construction operations develop, these plans, concepts and standards will be incorporated to provide a sound design for minimizing erosion. During the design phase, erosion control will be a critical aspect in designing facilities and structures. In connection with all design work, experienced field personnel will be involved to ensure that the policies and procedures established are considered and incorporated into operational activities.

(3) Construction and Operational Activities

The construction phase is clearly the most critical in terms of erosion control problems. It is at this stage that major disturbances affecting erosion control will occur. Construction contracts will include detailed descriptions of erosion control objectives, standards and design features. The Lessee will emphasize the importance of such work and undertake field review of the contractors' work to insure that objectives and planning goals are met.

Considerable land disturbance has already taken place on the Tract, particularly the chaining of extensive areas of pinyon-juniper by the Bureau of Land Management prior to 1967. Over 45% of the Tract area was chained. No efforts were made at that time to suppress dust or to control water erosion.

Since the acquisition of the Lease, the Lessee has conducted initial exploratory and drilling activities on the Tract. These activities have resulted in some minor land disturbances for drilling pads, road construction, construction of buildings at the temporary support facility, the installation of meteorological towers and other on-tract monitoring facilities. These activities have been conducted using erosion control techniques, and the results have been inspected by the AOSS and OSEAP. No significant adverse effects have occurred.

Under an approved DDP, the additional major earth disturbance activities which take place will increase the erosion potential. Depending upon the particular circumstances, various techniques will be employed to control erosion.

b. Erosion Control Methods and Application

Erosion begins when small particles of soil are picked up and carried away either by running water or wind. Erosion is a natural process which occurs everywhere. When it occurrs in a steady, limited manner, it does not have major negative effects. However, when the process is exaggerated and occurs too rapidly, the effects on land, water, animals and humans can be harmful. Although there is considerable overlap, erosion control techniques can be grouped into surface erosion control and stream flow control. These methods are discussed below.

(1) Surface Erosion Control

(a) Cuts and Fills

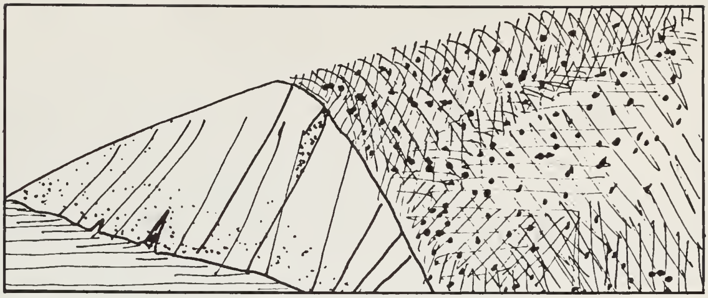
Development activities on the Tract will necessitate making numerous cuts and fills for dams, roads, plant and mine sites, etc. Since cuts and fills are usually designed with steep slopes in order to reduce the area disturbed and conserve material, rapid erosion of these surfaces can occur. However, due to the nature of the material that will be excavated, the erosion potential on major cuts and fills on the Tract is expected to be minimal.

It is anticipated that all significant excavations (cuts) on the Tract will be made substantially in weathered rock. Consequently, the permanent surfaces of major cuts are expected to provide excellent erosion resistant materials. Likewise, as the major fills will be comprised primarily of coarse broken rock, erosion of these slopes is expected to be minor.

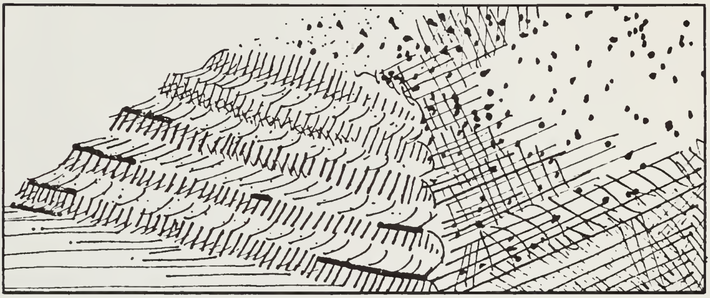
The side slopes in shallow cuts in rock and shallow rock fills will be relatively flat to accommodate a talus-soil cover that will facilitate permanent erosion control by revegetation. If cover material is finely divided, correct slope design is especially important. Such material may remain stable on short or flat slopes but will require additional attention on long or steep slopes.

Benching is an erosion control method which reduces the length of a cut or fill slope by dividing it into several small slopes. Benches are beneficial because they break the velocity of flow, allow water to be drained and diverted to reduce the flow on slopes, allow flat places for vegetation to grow, and facilitate maintenance (reseeding, cleaning). However, benching results in increased excavation and more land area is exposed unless slopes are made steeper. In spite of this disadvantage, control by benches or similar features has produced good and consistent results in reducing erosion. In addition, benching can be used as a landscape design technique. Since both erosion control and landscape efforts are assisted by benching and vegetation, benching of slopes on the Tract will be used wherever practical.

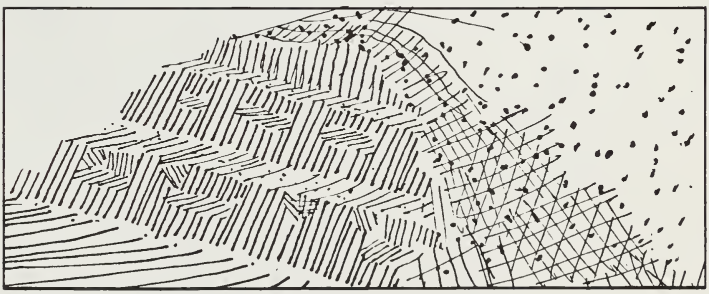
Depending on the location, size of the slope, presence of ground-water, soil conditions, etc., benches can be constructed in many shapes and sizes. In addition, several types of benching arrangements can be used together. The more variation introduced, the better the visual effect. (Figure V-31). "Mini"-benching is of particular value to revegetation efforts (Figure V-32). With this technique, multiple small pockets are left on the flat or sloped surfaces to create favorable microclimatic areas. Moisture accumulation and retention are enhanced by collection of precipitation. The selective and sparse use of relatively



Basic Cut or End of Disposal Pile

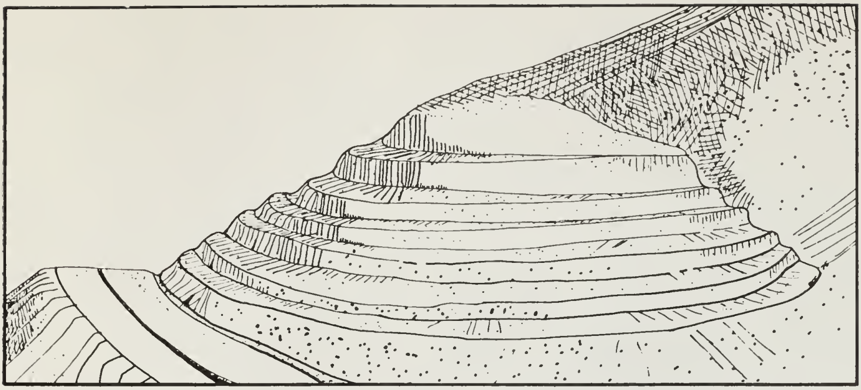


Simple Benching

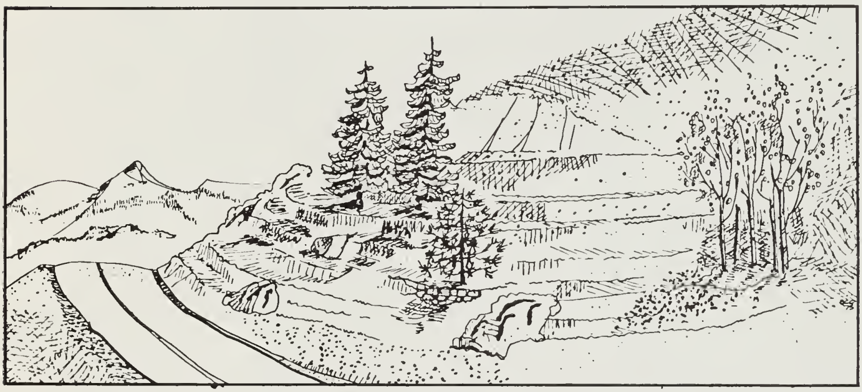


Staggered Benching

Figure V–31 BENCHING ARRANGEMENTS



Staggered Benching and Occasional Slope Rounding



Staggered Benching and Slope Rounding with Vegetation Pockets

Figure V–31 BENCHING ARRANGEMENTS (continued)

large rocks to provide shade or serve as snow and water traps can be included in this treatment.

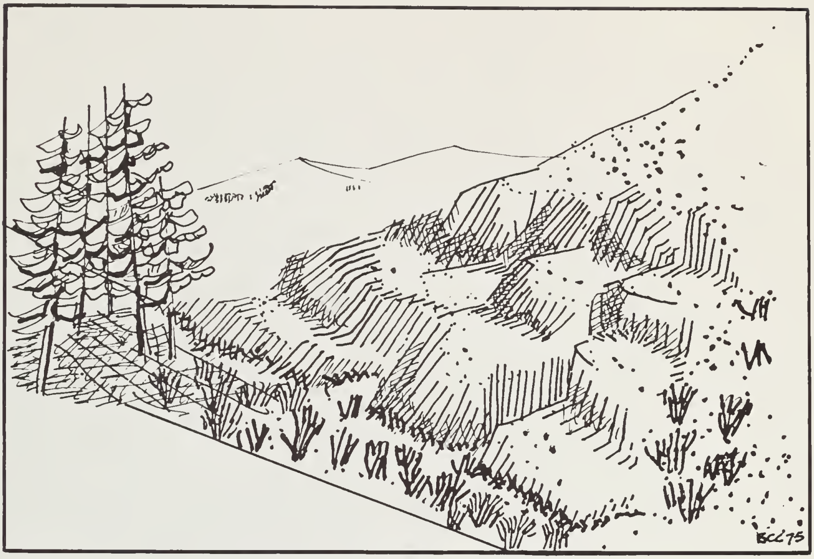
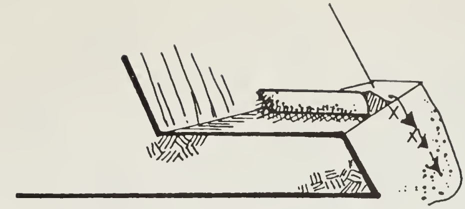


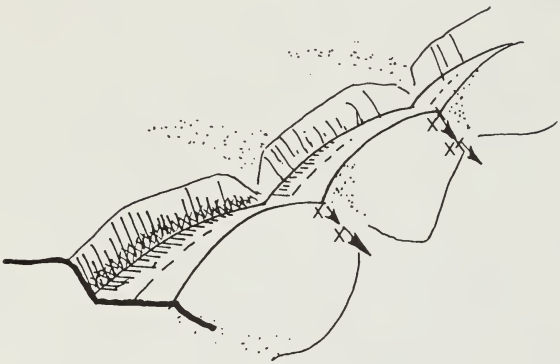
Figure V–32 INFORMAL (Mini) BENCHES

(b) Runoff Control

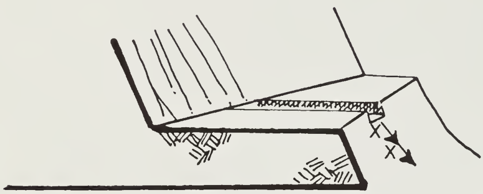
Another basic technique to minimize erosion is to keep runoff water from reaching the surfaces that are to be protected. Intercept or ditches, dikes and drains are used to accomplish this. Proper design, adjusted for experience gained during construction, will ensure proper location and dimensions. Interceptor dikes or ditches will be used above cut and fill slopes to intercept runoff and divert it around slopes where appropriate. Cross drains such as water bars, dips or pipe culverts will be used to carry runoff from cut slopes and roadside ditches across roadways (Figure V-33). Special drop structures may be used to allow water to flow or drop through considerable elevations without cutting into natural underlying materials. Formal runoff drainage systems will be used for permanent structures. Paving, curbs, gutters, ditches and dikes, inlets, underground collection systems, etc., will be used in connection with plant and mine surface areas, roadways, parking



Water Bars



Broad Based Dips



Open Culverts

NOTE: X's on drawings denote prime erosion areas.

Figure V–33 RUNOFF CONTROL – CROSS DRAINS

lots and other permanent facilities.

The spreading of water flows may also be used in certain circumstances as a runoff control measure. Spreading is designed to dissipate water that flows in a channel by splitting and spreading it over a surface area. Only water of acceptable physical and chemical characteristics can be handled in this manner. Much of the water which is spread will infiltrate into the ground, depending on percolation rates, the layout of spreading arrangements and channel geometry. Coordination between spreading and revegetation efforts will be stressed. Spread ditches provide ideal sites for plant growth because of the additional moisture that is available.

(c) Temporary Slope Protection

Temporary slopes and open areas that are to be revegetated at a later date must be provided with temporary erosion protection. This will be accomplished by using natural and commercial binders and/or coverings. A cover material applied as an initial step in revegetation should have good mulching characteristics. Some possible cover materials, their application rates and characteristics are:

- straw - 2 tons/acre - versatile, effective and easily obtainable, but susceptible to wind damage; straw is much preferred to hay
- biodegradable chemical binders - various sprays of dust stabilizants or actual glue-like substances; these penetrate somewhat before setting and combine with the individual soil particles to form a mat
- cellulose fiber - 1 ton/acre - can be applied while hydroseeding
- jute netting, mats - temporary but faster, easy to apply and provide good, instant ground cover; do not hamper revegetation efforts
- plastic mats and nets over hay and straw - give excellent, lasting cover; vegetation will grow through cracks and seams

Because seeding and planting operations are seasonally restricted, slopes constructed between seasons are vulnerable to erosion. Therefore, both during and subsequent to construction, sufficient temporary cover material will be on hand to cover all open, exposed slopes requiring protection. Sloped areas consisting of over 50% loose rock, talus or other block material will not normally require cover, and benches normally need not be covered. The large amount of rock and talus materials on the Tract will substantially reduce the number of slopes that will require temporary protection.

(d) Limiting Exposed Surfaces

Grading and cover efforts will be done in stages to limit the amount of open, exposed areas of surface at any one time. Plans and specifications will include major slope-forming activities, and will limit the amount of time temporary slopes and disturbed surfaces are exposed. These plans and specifications will be included in construction contracts.

(e) Wind Erosion Control

Although rainfall over a given area is generally uniform without regard to terrain, winds on the Tract can and do vary both in occurence and intensity. According to climatological data, the winds are most severe on exposed ridges and at higher elevations. In those areas, wind erosion will be reduced by natural wind breaks or by the use of wood or metal structures.

Snow drifting is a special form of wind erosion (and deposition) which can influence the operations and use of roads, stockpiles, parking lots, etc. Methods of controlling blowing snow will be analyzed and incorporated during engineering design.

(2) Stream Flow Control

In stream flow control, areas of concern include sedimentation, flow concentration, energy dissipation, stream crossings, and channel modification.

(a) Sedimentation

Despite conscientious control efforts, it is difficult to prevent at least some erosion during large earth moving projects. If not controlled, the resulting sediments (mainly fine sand, silt and clay) could be carried by flood waters and cause downstream damage.

The principal technique for retaining sediments is to retard their flow by filtering or ponding. Vegetation also can be a valuable asset in reducing flow, since brush and trees will reduce velocity along the edges of creeks and streams.

In order to minimize sediment loads reaching Piceance Creek, retention methods including traps, barriers and dams will be used in drainages downstream of disposal fills, roadway grading areas and extensively leveled areas (plant site, etc.). Temporary "dry basins" will be installed in the waterways of drainage areas where construction takes place. In the event of flooding, these barriers will act as temporary lakes where the coarser suspended sediments can settle before the relatively clean overflow is dispersed downstream. Small diversion structures will also be built to intercept runoff from exposed areas and divert it to safe disposal areas. Because a dam will be located at the lower end of Sorghum Gulch (below the area where most earth moving activities will be concentrated), little sediment is expected to reach Piceance Creek.

(b) Flow Concentration

A major problem in any grading activity is that it tends to concentrate runoff and increase flow velocity at locations where previously the flow had been more dispersed. Drainage modifications can affect flow concentration in several ways: 1) where existing channels are re-routed through culverts, ditches or channel changes, much higher outlet velocities can be reached at the release point; 2) when existing sheet flow on natural slopes is intercepted and collected, runoff concentration can occur where no flows occurred previously; 3) when artificial cover is placed on surface areas (e.g., roofs, parking lots and roads), runoff can increase and exceed the capacity of existing channels.

As previously discussed, adequate drainage must exist for each activity planned. Depending upon the facility in question, such drainage can be provided in a variety of ways, including pipelines, collector ditches, culverts, berms, underdrains and gutters.

Water flows created on the Tract will be designed to take advantage of natural phenomena. Design elements will be keyed to natural conditions such as the shape and proportion of slopes and ditches, the flow-line elevation of culverts, velocity control at the outlets of structures, and the size of riprap, rocks or gravel used for bottom or bank protection.

The following principles will be followed to minimize flow concentration:

- change existing channels as little as possible
- protect existing vegetation
- put special emphasis on retaining original bed material
- where changes are inevitable, provide material of same or similar nature

Outlet velocities and channel capacities will be designed to avoid scouring or silt deposition. Low stages of water flow and the possibility of small floods will be considered in planning, as well as the 100-year flood.

(c) Energy Dissipation

Energy dissipation will be required where large flow volumes and energies occur. Several types and sizes of energy dissipation structures will be used. The most natural-looking dissipation structures will be built by using loose native rocks and boulders, which make ideal outlet barriers for culverts. More elaborate structural arrangements such as weirs, barriers and bed stabilization may also be required (Figure V-34).

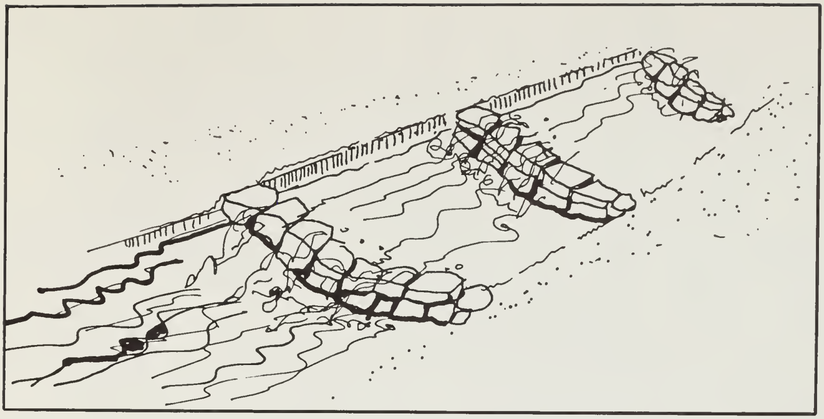


Figure V—34 ENERGY DISSIPATORS

For larger flows, dissipation structures must be constructed to handle not only the larger volumes of water, but also silt, sand and other material that might settle. Economic and aesthetic considerations will determine the choice of construction materials such as: gabions of wire mesh or rock netting, riprap or other rock masonry, concrete, and other materials such as logs, metal cribbing, etc. Provisions for cleaning the settlement basin will be incorporated into the design.

Though stream flow doesn't occur during most of the year on most of the Tract, specific channel protection may be required in connection with development features such as diversion channels, spillways and road or pipeline crossings. Bank and bottom stability will be achieved by using cover material of sufficient size and using appropriate revegetation techniques. Some riprap may be required. Special attention will be given to all transition sections, where flow is released into an existing, natural stream bed. Experience has shown that when not enough bed and slope protection is provided, undercutting and washing results. Changes in drainage patterns may also result in higher rates of discharge. Downstream channels will be protected so they can handle the higher flows without washing or undercutting of banks.

(d) Stream Crossings

Crossings of intermittent streams on-tract will be designed carefully. To allow natural flows to continue uninterrupted, a large, clear opening that restricts neither direct nor adjacent flood plain areas will be provided. During construction, care will be taken to avoid unnecessary encroachment by equipment and materials. Particular emphasis also will be placed on preserving any existing vegetation adjacent to waterways. Where it is not possible to avoid damage, mitigating steps will be taken to diminish the extent and length of encroachment as much as possible, and to reconstruct the bed, banks and vegetation as quickly as possible.

Permanent crossings of intermittent streams will be designed to:

- avoid high velocities by minimizing submergence at inlet
- minimize gradients
- provide energy dissipation at outlets
- provide extra drainage roughness (riprap) downstream of outlet structure
- place flowline according to accepted practices and standards
- provide good maintenance

Piceance Creek is the only continuously flowing stream near the Tract that will potentially be affected by development. The natural waterway of this drainage at the access road crossing will be disturbed only as required for installation of a bridge or culvert.

(e) Channel Modifications

When possible, channel modifications will be designed for flood requirements, but shaped so that flows of one-half the mean annual flood flow velocities are about two feet per second. Banks will be as rough and irregular in alignment and grade as possible. Bottom profiles will include breaks and pools. When channel changes occur, efforts will be made to introduce vegetation of various kinds quickly.

4. Surface Rehabilitation Plan, Including Demonstration of Technology for Revegetation

a. Introduction

Revegetation of disturbed areas is both an erosion control technique and a means of enhancing forage, wildlife, aesthetic and other values. This plan contains both the methods to be used in revegetation of disturbed areas, including processed shale, and a demonstration of the technology which is available for revegetation.

A series of studies, experiments, and field demonstrations have been carried out since 1965 relating to the development of methods and techniques for revegetation of processed shale from the TOSCO II retort. The principal studies, which have been published in a Colony Development Operation document entitled "Processed Shale Revegetation 1965 - 1973" are summarized in Table V-33.

Table V–33 SHALE REVEGETATION STUDIES – TOSCO II PROCESSED SHALE

Study Title	Description
1965 Denver Field Experiment (Haberman, 1973)	First field plots established to test growth of grass in processed shale.
Some Properties of Spent Oil Shale Significant to Plant Growth (Schmehl and McCaslin, 1973)	Tests determined chemical and physical properties of processed shale as they related to revegetation.
1967 Field Experiments at Parachute Creek (Bradshaw, 1973)	First field trials at Parachute Creek to test growth of various species.
1968-1969 Semi-works Plot Field Experiment (Schaal, 1973b)	New plot established on semi-works embankment to test growth of grasses and woody plants.
Greenhouse Experiments of Plant Growth in Processed Shale (Schaal, 1973a)	Greenhouse experiments to further define species and soil treatment.
Vegetation Establishment Demonstration (1971) on TOSCO II Processed Shale (Bert, 1973b)	New demonstration plot established to show effects of nutrients, cover, water and mulching and optimum seeding mixtures.
Performance of Plants with Minimal Treatment of Processed Oil Shale (Merkel, 1973)	New plots established to determine ability of selected plant species to survive in processed shale without irrigation.
1973 Annual Revegetation Report (Baker and Duffield, 1973a)	New replicated plots established to compare growth on different substrates from pure processed shale to shale with soil covers.
1973 Annual Revegetation Report (Baker and Duffield, 1973a)	Stabilization study testing various amounts of mulches and chemical soil binders on existing embankment.
1973 Annual Revegetation Report (Baker and Duffield, 1973a)	A new demonstration plot comparing soil and processed shale substrates on the plateau top.
Long-Range Plan for Revegetation Studies, 1973-1978 (Dwyer, 1973)	Long-range plan from continuing studies on each of the existing plots.

The field demonstration plots identified in studies listed in Table V-33 are located on or near the Colony Development Operation property near Parachute Creek, where they are open to public inspection. These plots amply demonstrate that processed shale can be revegetated on a self-sustaining basis.

It is the intent of the C-b Shale Oil Project to rehabilitate lands disturbed during the development of oil shale resources on the Tract in a manner consistent with good ecological practices, economic feasibility and practical land use considerations. To accomplish these goals, a revegetation plan has been developed to:

- stabilize and control erosion on disturbed surfaces by using plant materials
- support animal populations at least as extensive as those presently on the Tract
- coordinate the natural processes of ecosystem recovery which occur independent of man by using the best available management practices

The guidelines presented in this plan are intended as a general format within which specific procedures can be developed. This format will apply in general to the two types of revegetation which are important on the Tract: 1) the re-establishment of plant cover on sites disturbed during the exploration and development phases of the project; and 2) vegetation of processed shale after the mining and retorting operation begins. The first will be an immediate need; the second is a long-term project.

Major types of sites requiring revegetation of disturbed soils include abandoned drill pads, access roads, mine and plant sites, support facilities, diversion systems and other cleared support sites. A detailed descripton of these activities can be found in Sections II and III. The size of areas to be disturbed has been previously described (Table V-16). The revegetation of these sites will follow conventional techniques. All techniques used will be evaluated to determine their suitability in establishing vegetation for the support of existing animal populations. Aesthetics will also be considered.

This plan addresses the overall approach and strategies selected to meet the criteria stated above. Revegetation activities fall into two major categories: 1) planning and design; and 2) implementation. The planning and design category includes the formulation of planting techniques, development of methods for evaluation of site success, and the integration of baseline data and other pertinent information into initial plans and later program modifications.

The implementation category includes site preparation, planting, maintenance, and the evaluation of site success.

Responsibility for planning, design and implementation will be shared by the staff and field personnel who design the plan specifics integrate the plans with other management plans, the baseline studies and current data; and coordinate the activities with the AOSS and the Bureau of Land Management (BLM) and finally, implement and evaluate the Surface Rehabilitation Plan.

b. Revegetation of Disturbed Areas Other than Processed Shale

The rehabilitation of sites disturbed during exploration and development will be initiated before development begins and will continue through the developmental period. Areas disturbed by activities other than those relating to the disposal of mine and retort wastes will be rehabilitated by procedures discussed in this portion of the Surface Rehabilitation Plan. This portion of the plan provides for biological erosion control on disturbed sites through the rapid establishment of vegetation. It also allows for the eventual reestablishment of native vegetation through the use of carefully selected seed varieties and planting methods. The generalized procedures presented here are meant to act as a basis for the development of more specific plans immediately prior to any specific revegetation activity. Specific planting plans will be developed after a physical evaluation of each site, and will follow the general procedures outlined below, modified as required by any relevant baseline data.

(1) Timing

Revegetation of disturbed areas will be controlled generally by the activity schedules outlined in Sections II and III. Once an activity has been completed, a site-specific revegetation plan will be prepared and carried out as promptly as possible. In most cases the timing of seeding may be critical. Thus limited delays may occur in waiting for the appropriate planting season. In all cases revegetation will occur within one year of completion of an activity and generally much sooner.

(2) Techniques and Materials

Guidelines will be followed in the preparation of the site-specific plans which will be used for each area requiring revegetation. An example of a planting plan for a disturbed site is shown in Table V-34. Tables V-35 and V-36 and the following discussions present the guideline plans for revegetating disturbed areas on the Tract. They are subject to change as new technology, information and experience become available.

(a) Seed Selection

Seed mixtures will be developed according to topography, soil moisture and adjacent vegetation, and will incorporate information

Table V–34 EXAMPLE OF REVEGETATION
SITE PLANTING PLAN

SITE DESCRIPTION AND LOCATION Air Quality-Met Tower, Chained Pinyon-Juniper

PLANTING PERIOD Oct. 15 - Nov. 15 SEED APPLICATION broadcast and drill

SEEDBED PREPARATION hand scarification

MULCHING TREATMENT distribute slash

FERTILIZER none

FENCING none REMARKS provide gravelled access to tower and instrument trailer

SPECIES LIST AND RATE

COMMON NAME	SCIENTIFIC NAME	VARIETY	LBS/ACRE
Siberian wheatgrass	Agropyron sibiricum		2
Intermediate wheatgrass	Agropyron intermedium	Amur	2
Western wheatgrass	Agropyron smithii	Rosana	2
June grass	Koeleria gracilis		2
Indian ricegrass	Oryzopsis hymenoides		1
Slender wheatgrass	Agropyron trachycaulum		1
Mountain mahogany	Corcocarpus montanus		1/2
Snowberry	Symphoricarpos oreophilus		1/2
Sweetvetch	Hedysarum boreale	Utah	1/2
		TOTAL LBS/ACRE	11½

Table V-35 GUIDELINES FOR SEED MIXTURES ON DISTURBED AREAS

All seed mixtures in lbs./acre Species	Air Quality Met. Tower, chained pinyon-juniper	A-1, bottomland sagebrush, near main turnoff on Piceance Creek road	A-2, bottomland sagebrush, Pasture	A-3, bottomland sagebrush, in Scandard Gulch	A-4, bottomland sagebrush, head of Scandard Gulch	A-5, bottomland sagebrush, on Piceance Creek at mouth of Cottonwood Gulch	A-6/SG20 bottomland sagebrush, on Piceance Creek road, big cut in hillside next to it	A-7/SG19 bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch
Agropyron intermedium (amur) – intermediate wheatgrass	2	3		3	3	2	2	2
Agropyron trichophorum pubescent wheatgrass	2	3		3	3	3	3	3
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	3		3	3	2	2	2
Agropyron trachycaulum slender wheatgrass	1							
Corcocarpus montanus mountain mahogany	1/2							
Elymus cinereus Great Basin wildrye						1	1	1
Hedysarum boreale (Utah) sweetvetch	1/2	1/2		1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2							
Oryzopsis hymenoides Indian ricegrass	1	1		1	1	1	1	1
Purshia tridentata antelope bitterbrush	1/2	1/2		1/2	1/2	1	1	1
Stipa comata needle and thread	1	1		1	1	1/2	1/2	1/2
Symphoricarpus oreophilus snowberry	1/2							
TOTAL	11½	12	0	12	12	11	11	11

Table V-35 (Continued)

All seed mixtures in lbs./acre Species	SG14/A10 bottomland sagebrush, Middle Stewart Gulch	SG15, chained pinyon-juniper, ridge between Scandard and Sorghum Gulches	SG16, chained pinyon-juniper and upland sage, site near Vegetation Plot #3	SG17 pinyon-juniper ridge between West Stewart and Middle Stewart Gulches	SG18, 18a upland sage-brush, head of Sorghum Gulch	SG-19/A-7, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	SG20/A-6 bottomland sage-brush, on Piceance Creek road, big cut in hillside next to it	SG21, bottomland sage, Scandard Gulch
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	2	2	2	2	3
Agropyron sibircum Siberian wheatgrass	3	2	2	2	2	3	3	3
Bromus marginatus mountain brome	2	2	2	2	2	2	2	3
Agropyron smithii (rosana) – western wheatgrass		1	1		1			
Agropyron trachycaulum slender wheatgrass				1				
Corcocarpus montanus mountain mahogany		1/2	1/2		1/2			
Elymus cinereus Great Basin wildrye	1					1	1	
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2		1/2	1/2	1/2	1/2
Koeleria gracilis June grass		2	2	2	2			
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush	1			1/2		1	1	1/2
Stipa comata needle and thread	1/2					1/2	1/2	1
Symphoricarpus oreophilus snowberry		1/2	1/2	1/2	1/2			
TOTAL	11	11½	11½	11	11½	11	11	12

Table V–35 (Continued)

All seed mixtures in lbs./acre	SG6, chained pinyon-juniper, ridge west of Sorghum Gulch	SG-7/NQ7, chained pinyon-juniper, ridge west of West Stewart Gulch	SG8/A9, bottomland sage-brush, near Oldland Summer Camp	SG9, chained pinyon-juniper, ridge above Scandard Gulch	SG10, upland sage/chained pinyon-juniper, near met. tower	SG11, chained pinyon-juniper, ridge east of Sorghum Gulch	SG12/NQ12, chained pinyon-juniper, ridge east of Sorghum Gulch	SG13, chained pinyon-juniper, lower ridge west of West Stewart Gulch
Species								
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	2	2	2	2	2
Agropyron sibircum Siberian wheatgrass	2	2	3	2	2	2	2	2
Bromus marginatus mountain brome				2	2	2	2	2
Agropyron smithii (rosana) – western wheatgrass	2	2	2	1	1	1	1	1
Agropyron trachycaulum slender wheatgrass	1	1						
Corcocarpus montanus mountain mahogany	1/2	1/2		1/2	1/2	1/2	1/2	1/2
Elymus cinereus Great Basin wildrye			1					
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2	2		2	2	2	2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush								
Stipa comata needle and thread			1/2					
Symphoricarpus oreophilus snowberry	1/2	1/2		1/2	1/2	1/2	1/2	1/2
TOTAL	11½	11½	11	11½	11½	11½	11½	11½

Table V–35 (Continued)

All seed mixtures in lbs./acre	NQ4, chained pinyon-juniper, ridge west of Scandard Gulch	NQ7/SG-7, chained pinyon-juniper, ridge west of West Stewart Gulch	NQ12/SG12, chained pinyon-juniper, ridge east of Sorghum Gulch	SG1, bottomland sagebrush, mouth of Scandard Gulch	SG2, chained pinyon-juniper, ridge west of Cottonwood Gulch	SG3, chained pinyon-juniper, ridge east of Sorghum Gulch	SG4, chained pinyon-uniper, ridge between Scandard and Little Scandard Gulches	SG5, chained pinyon-juniper west of support facility
Species								
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	3	2	2	2	2
Agropyron sibircum Siberian wheatgrass	2	2	2	3	2	2	2	2
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	2	2	3	2	2	2	2
Agropyron trachycaulum slender wheatgrass	1	1	1		1	1	1	1
Corcocarpus montanus mountain mahogany	1/2	1/2	1/2		1/2	1/2	1/2	1/2
Elymus cinereus Great Basin wildrye								
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass	2	2	2		2	2	2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush				1/2				
Stipa comata needle and thread				1				
Symphoricarpus oreophilus snowberry	1/2	1/2	1/2		1/2	1/2	1/2	1/2
TOTAL	11½	11½	11½	12	11½	11½	11½	11½

Table V-35 (Continued)

All seed mixtures in lbs./acre	A-8, bottomland sagebrush, Lower Stewart Gulch	A-9/SG8, bottomland sagebrush, near Oldland Summer Camp	A-10/SG14, bottomland sagebrush, Middle Stewart Gulch	A-11, bottomland sagebrush, West Stewart, just past turnoff to ridge to met. - tower	A-12, bottomland sagebrush, Upper West Stewart Gulch	A-13, bottomland sagebrush, in wash at head of Sorghum Gulch	Cb2, chained pinyon-juniper ridge east of Cottonwood Gulch	Cb4, chained pinyon-juniper ridge west of West Stewart Gulch
Species								
Agropyron intermedium (amur) – intermediate wheatgrass	2	2	2	2	2	2	2	2
Agropyron trichophorum pubescent wheatgrass	3	3	3	3	3	3	2	2
Bromus marginatus mountain brome								
Agropyron smithii (rosana) – western wheatgrass	2	2	2	2	2	2	2	2
Agropyron trachycaulum slender wheatgrass							1	1
Corcocarpus montanus mountain mahogany							1/2	1/2
Elymus cinereus Great Basin wildrye	1	1	1	1	1	1		
Hedysarum boreale (Utah) sweetvetch	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Koeleria gracilis June grass							2	2
Oryzopsis hymenoides Indian ricegrass	1	1	1	1	1	1	1	1
Purshia tridentata antelope bitterbrush	1	1	1	1	1	1		
Stipa comata needle and thread	1/2	1/2	1/2	1/2	1/2	1/2		
Symphoricarpus oreophilus snowberry							1/2	1/2
TOTAL	11	11	11	11	11	11	11½	11½

Table V–36 GUIDELINES FOR REVEGETATION PROCEDURES ON DISTURBED AREAS

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
Air Quality Meteorological Tower, chained pinyon-juniper	Oct. 15 - Nov. 15	broadcast and drill	hand scarification	distribute slash	none	none	provide gravelled access to tower and instrument site
A-1, bottomland sagebrush, near main turnoff on Piceance Creek road	Oct. 15 - Nov. 15	drill	harrow lightly with pipe harrow	none	none	none	favorable site for rehabilitation
A-2 bottomland sagebrush, pasture	----	----	none, leave as is	----	----	----	vegetation cover has been naturally established
A-3, bottomland sagebrush, in Scandard Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	none	less than 1/10 acre next to road, favorable site
A-4, bottomland sagebrush head of Scandard Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	none	favorable site, western wheatgrass seedlings scattered
A-5, bottomland sagebrush on Piceance Creek at mouth of Cottonwood Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-6/SG-20, bottomland sagebrush, on Piceance Creek road, big cut in hillside next to it	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-7/SG-19, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
A-8, bottomland sagebrush, lower Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site
A-9/SG-8, bottomland sagebrush, near Oldland Summer Camp	Oct. 15 - Nov. 15	drill	harrow lightly, pit needs cover and litter cleanup	----	----	already in fenced area	area could also be smoothed when pit is covered up
A-10/SG-14, bottomland sagebrush, Middle Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	5 foot cut on west side may require broadcast seeding and mulch excelsior

Table V–36 (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
A-11, bottomland sagebrush West Stewart, just past turnoff to ridge met. - tower	Oct. 15-Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site
A-12, bottomland sagebrush, upper West Stewart Gulch	Oct. 15 - Nov. 15	drill	lightly harrow	none	none	3 strand barbwire	favorable site
A-13, bottomland sagebrush in wash at head of Sorghum Gulch	Oct. 15 - Nov. 15	drill with some broadcasting	lightly harrow	none	none	none	favorable site, small area about 20 to 50 feet
C-b2, chained pinyon-juniper, ridge east of Cottonwood Gulch	Oct. 15 - Nov. 15	drill and broadcast	pad requires minimal roughing; no recontouring is necessary	none	none	none	this site shows voluntary establishment of permanent vegetation
C-b4, chained pinyon-juniper ridge west of Stewart Gulch	Oct. 15 - Nov. 15	broadcast and drill	minor ripping and scanfication, recontour	none	none	none	- - - -
NG4, chained pinyon-juniper ridge west of Scandard Gulch	Oct. 15 - Nov. 15	drill and broadcast	lightly harrow after recontouring	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	include roadway; water bars needed on roadway site
NQ7/SG-7 chained pinyon-juniper, ridge west of West Stewart Gulch	Oct. 15 - Nov. 15	broadcast and drill	rip and cover with available fine material	replace slash	none	none	- - - -
NQ12-SG12, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	broadcast and drill	recontour pad; rough and distribute slash	none	none	none	no monitoring access required; some device needed to prevent vehicular traffic
SG1, bottomland sagebrush, mouth of Scandard Gulch	Oct. 15 - Nov. 15	drill	(pad has been prepared)	none	none	3 strand barbwire	access for well monitoring required
SG2, chained pinyon-juniper ridge west of Cottonwood Gulch	Oct. 15 - Nov. 15	drill and broadcast	recontouring followed by light harrowing	straw or excelsior on cat area	less than 80 lbs. available N.P.K./acre in summer of 1976	none	cut slope requires broadcasting and mulching
SG3, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -

Table V–36 (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
SG4, chained pinyon-juniper ridge between Scandard and Little Scandard Gulches	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG5, chained pinyon-juniper west of support facility	Oct. 15 - Nov. 15	drill and broadcast	light harrowing following re-contouring	possibly on 6 foot cut	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG6, chained pinyon-juniper ridge west of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	Fine material on edges of bed should be pulled back on pad. Slush should be spread on pad. Minimal roughing with pipe harrow; no contouring.	- - - -	none	none	retain gravel access to monitoring shea
SG7/NQ7, chained pinyon-juniper, ridge west of West Stewart Gulch	Oct. 15 - Nov. 15	broadcast and drill	rip and cover with available fine material	replace slash	none	none	- - - -
SG8/A-9, bottomland sagebrush, near Oldland Summer Camp	Oct. 15 - Nov. 15	drill	harrow lightly. Pit needs covered and litter cleaned up.	- - - -	- - - -	already in fenced-in area	area could also be smoothed when the pit is covered up
SG9, chained pinyon-juniper, ridge above Scandard Gulch	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG10, upland sage/chained pinyon-juniper, near met. tower	Oct. 15 - Nov. 15	broadcast and drill	pad needs minimal roughing and pipe harrow	none	none	none	maintain monitoring access
SG11, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	harrow lightly	none	less than 80 lbs. available N.P.K./acre in summer of 1976	none	- - - -
SG12/NQ12, chained pinyon-juniper, ridge east of Sorghum Gulch	Oct. 15 - Nov. 15	broadcast and drill	recontour pad; rough and distribute slash	none	none	none	no monitoring access required; some device needed to prevent vehicular traffic
SG13, chained pinyon-juniper lower ridge west of West Stewart Gulch	Oct. 15 - Nov. 15	drill and broadcast	light harrowing; restore contour	none	none	none	- - - -

Table V–36 (Continued)

Site Description and Location	Planting Period	Seed Application	Seedbed Preparation	Mulching Treatment	Fertilizer	Fencing	Remarks
SG14/A-10, bottomland sagebrush, Middle Stewart Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	5 foot cut on west side may require broadcast seeding and mulch excelsior
SG15, chained pinyon-juniper, ridge between Scandard and Sorghum Gulches	Oct. 15 - Nov. 15	broadcast and drill	rip surface recontour pad; pull back toe of pad; replace fine material stockpiled; distribute slash	- - - -	none	none	include several shrub species as transplants as follow-up
SG16, chained pinyon-juniper and upland sage, site near Vegetation Plot #3	Oct. 15 - Nov. 15	drill and broadcast	minimal roughing and pipe harrow; toe of pad should be pulled back	- - - -	none	none	place water bars adjacent to drainings to disperse runoff onto pad; plans include access roadway
SG17, pinyon-juniper, ridge between West Stewart and Middle Stewart Gulches	Oct. 15 - Nov. 15	broadcast	rip surface; replace debris and fine material	none	none	none	allow access through pad/shrub sod; pinyon and juniper set outs as follow-up
SG18a, upland sagebrush, head of Sorghum Gulch	Oct. 15 - Nov. 15	drill and broadcast	pad has been ripped and recontoured	none	none	3 strand barbwire	must allow access for monitoring and through pad
SG19/A-7, bottomland sagebrush, on Piceance Creek at mouth of Sorghum Gulch	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
SG20/A-6, bottomland sagebrush, on Piceance Creek road, big cut in hillside next to it	Oct. 15 - Nov. 15	drill	harrow lightly	none	none	3 strand barbwire	favorable site, base of north slope
SG21, bottomland sagebrush, Scandard Gulch	Oct. 15 - Nov. 15	drill	(seedbed has been roughed) terrace slopes above and below roadway	none	none	3 strand barbwire	fence pad on either side of road; plant shrub species on lower slope terraces

regarding previous vegetation. Table V-37 lists those species which have been successfully established in various habitats found in the Piceance Creek basin. The listed plant species are available from a number of commercial seed and plant material growers in the Western United States. Among these are three companies in Colorado and others in Utah, Kansas and Idaho. The suggested species for specific vegetation are discussed below.

Agricultural Areas. Pasture and hay lands in the Piceance Creek valley and tributary drainages should be easily revegetated. These sites will be seeded with species such as timothy (Phleum pratense), alfalfa (Medicago sativa) and wheatgrasses (Agropyron intermedium, A. sibiricum and A. trichophorum Other species such as sweetvetch (Hedysarum boreale) and yellow sweet clover (Melilotus officinalis) would also be suitable for these areas.

Bottomland Sagebrush Community. In order to establish initial ground cover in these communities, several species of wheatgrass (Agropyron sibiricum, A. intermedium, A. smithii, and A. trichophorum) would be suitable. Other species of grasses and forbs (herbaceous plants which are not grasslike) to be used, will include needle and thread (Stipa comata), sweetvetch (Hedysarum boreale), fleabane (Erigeron spp.), mariposa lily (Calochortus spp.) and scarlet globemallow (Sphaeralcea coccinea). Shrub species will also be considered for use in these sites. Species might include big sagebrush (Artemisia tridentata), rabbitbrush (Chrysothamnus nauseosus) and winterfat (Ceratoides lanata).

Plateau Sagebrush Community. Wheatgrasses will also provide a rapid initial cover on these sites (see above, bottomland sagebrush community). Additional grass species, including June grass (Koeleria gracilis), Indian ricegrass (Oryzopsis hymenoides) and needle and thread (Stipa comata) would be suitable for these sites. Several shrub species will be considered either for initial seeding or as transplants in a follow-up operation. Species would include big sagebrush (Artemisia tridentata) and rabbitbrush (Chrysothamnus nauseous).

Forb species which might be included in seed mixtures include mariposa lily (Calochortus spp.), Freemont's penstemon (Penstemon freemontii), scarlet globemallow (Sphaeralcea coccinea), milk vetch (Astragalus spp.) and sweetvetch (Hedysarum boreale).

Chained Pinyon-Juniper Community. Grasses which will be selected for use in seed mixtures on chained sites will include pubescent wheatgrass (Agropyron trichophorum), intermediate wheatgrass (A. intermedium), Indian ricegrass (Oryzopsis hymenoides), June grass (Koeleria gracilis), western wheatgrass (Agropyron smithii), and slender wheatgrass (A. trachycaulum). Forb species would include Freemont's penstemon (Penstemon freemontii), sweetvetch (Hedysarum boreale), and milk vetch (Astragalus spp.).

Table V–37 PLANT SPECIES SUITABLE FOR REVEGETATION OF DISTURBED SITES

GRASSES	
Agropyron elongatum	(tall wheatgrass)
Agropyron intermedium (amur)	(intermediate wheatgrass)
Agropyron sibiricum	(Siberian wheatgrass)
Agropyron smithii (rosana)	(western wheatgrass)
Agropyron trachycaulum	(slender wheatgrass)
Agropyron trichophorum	(pubescent wheatgrass)
Bromus marginatus	(mountain brome)
Elymus cinereus	(Great Basin wildrye)
Koeleria gracilis	(June grass)
Medicago sativa	(alfalfa)
Oryzopsis hymenoides	(Indian ricegrass)
Phleum pratense	(timothy)
Poa pratensis	(blue grass)
Sporobolus airoides	(alkali sacaton)
Stipa comata	(needle and thread)
FORBS	
Artemisia frigida	(pasture sage)
Artemisia ludoviciana	(sagewort)
Astragalus spp.	(milkvetch)
Calochortus nuttallii	(mariposa lily)
Clematis spp.	(virgin's bower)
Erigeron utahensis	(fleabane daisy)
Eriogonum umbellatum	(sulphur flower)
Hedysarum boreale (Utah)	(sweetvetch)
Melilotus officinalis	(yellow sweet clover)
Penstemon freemontii	(Freemont's penstemon)
Sphaeralcea coccinea	(scarlet globemallow)
SHRUBS	
Amelanchier alnifolia	(serviceberry)
Artemisia tridentata	(big sagebrush)
Atriplex spp.	(shadscale)
Ceratoides lanata	(winterfat)
Cercocarpus montanus	(mountain mahogany)
Chrysothamnus nauseosus	(rabbitbrush)
Purshia tridentata	(antelope bitterbrush)
Quercus gambelii	(Gambel's oak)
Sarcobatus vermiculatus	(greasewood)
Symphoricarpos oreophilus	(snowberry)
TREES	
Juniperus osteosperma	(Utah juniper)
Juniperus scopulorum	(Rocky Mountain juniper)
Pinus edulis	(pinyon pine)

Bunchgrass Community. Revegetation of these dry sites will be difficult because of low moisture and relatively unstable soil. The most suitable grasses are Indian ricegrass (Oryzopsis hymenoides), bluebunch wheatgrass (Agropyron spicatum), western wheatgrass (A. smithii), and needle and thread (Stipa comata). Two low-growing sage species suitable for these sites are sagewort (Artemesisa ludoviciana) and pasture sage (A. frigida). Forbs such as sulphur flower (Eriogonum umbellatum) would do well if "set out" during follow-up activities.

Pinyon-Juniper Community. The understory vegetation in these woodlands is variable. On those sites where the understory is poorly developed it will be best to either seed or transplant the tree species pinyon pine (Pinus edulis) and juniper (Juniperus osteomosperma and/or J. scopulorum). If this is prohibitive, some improvement of the site to prepare it for natural tree seed invasion might be provided by maintenance, fertilization of sites and mulching with slash material. Grass species which can be used on these sites for initial vegetation cover would include wheatgrasses (Agropyron smithii, A. intermedium, A. trichophorum), Indian wheatgrass (Oryzopsis hymenoides) and June grass (Koelerai gracilis). Shrub species for these sites for initial vegetation cover would include mountain mahogany (Cercocarpus montanus), serviceberry (Amelanchier alnifolia), snowberry (Symphoricarpos oreophilus) and bitterbrush (Purshia tridentata). Pinyon-juniper sites with well developed understory vegetation adjacent to them should be seeded with the grass and shrub species listed above.

Mixed Mountain Shrub Community. Mixed mountain shrub stands are located on moist soils and should not be difficult to revegetate. They will, however, require a relatively long period of time for reestablishment of shrubby vegetation, and should be planted with shrub seed and/or transplants. Grasses suitable for initial cover include western wheatgrass (Agropyron smithii), intermediate wheatgrass (A. intermedium), pubescent wheatgrass (A. tricophorum), bluegrasses (Poa pratensis and P. ampula) and Indian ricegrass (Oryzopsis hymenoides). Shrubs should include Gambel's oak (Quercus gambeli), mountain mahogany (Cercocarpus montanus), bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus) and serviceberry (Amelanchier alnifolia) Forbs such as virgin's bower (Clematis spp.) might also be used.

(b) Fertilizer

Restoration of vegetation is more easily and rapidly achieved by increasing soil fertility. Soil sampling to determine fertility will help define fertilization needs (Section XII on Soil Productivity).

Fertilizer applications should be well timed. Available nitrogen in sulfate or urea form should be applied in the fall, before the first snow; available nitrogen in nitrate form is applied in the spring. Fertilization during the early summer following seeding will produce good results.

(c) Mulch Selection

Acceptable mulching materials include excelsior blanket, jute mesh, wood fiber and native hay or straw. All types will act to retain soil moisture in an arid climate. Each has disadvantages and advantages of its own: excelsior blanket tends to decrease soil temperature; jute mesh tends to increase soil temperature because of a lack of shading. Both are fire retardant and weed free, though jute is not easily applied to rocky terrain. Wood fiber is costly, subject to wind damage, and can cause seeds to become caught above ground. On the other hand, it is easily applied to steep slopes and is fire resistant. Native hay or straw is fire prone, but is the most versatile mulch. It combines the advantages of moisture retention, a balanced heat regime, and an additional source of native seed. Hay and straw, however, often contain a high percentage of weed annuals which are undesirable because they may compete too strongly with the permanent-successional species. The choice of mulch depends on the characteristics of the individual sites. The suggested types are wood fiber and excelsior.

(d) Seedbed Preparation

An important feature in vegetation is microclimate. Microclimate effects can be obtained by using small terraces and furrows. These will provide protection from the sun's drying effects, will produce locally moist areas, and will also retard erosion caused by runoff.

(e) Seeding and Mulching Operations

Seeding can be accomplished by the use of a hand seeder, or by hydroseeding or drilling. Drilling seed helps seed germination where soil moisture is deficient. It has the disadvantage, however, of producing a row effect that may not be effective in stemming erosion and which may produce open soil areas that could be invaded by aggressive winter annuals. Hand seeding is the most time consuming and laborious method, but has shown good results in a variety of areas. Hydroseeding is a time-saving method which also provides an initial application of water that can help germination. However, the application of water in the wrong season (i.e., early fall), will cause poor root development and short-lived growth. Irrigation of plantings should be done early in the growing season to aid the establishment of seedlings. If hydroseeding and mulching (wood fiber mulch) are to be used together, the seed should be applied first, followed by mulch. If it is desirable to apply both in one operation, the seed amount should be doubled since a certain amount of seed is likely to become hung up in the mulch instead of reaching the soil. Seeding rates will vary between sites and with different planting methods. Applications of between 10 pounds and 30 pounds per acre (depending on the planting method) should result in good stands.

(f) Planting Time

The best time for planting in the Piceance Creek basin is late in the growing season (September-November), since this enables the seedlings to become established early in the next growing season when soil moisture is not a limiting factor. Construction times should be coordinated to coincide with favorable planting times. Spring planting, in April and May, may also be feasible.

(g) Invasions

Several plant species are known to be highly competitive in the Tract area and can be expected to invade and establish themselves in the replanted stands. The strongest of these is cheatgrass (Bromus tectorum). Cheatgrass is a hardy, winter annual known for its ability to compete successfully with native perennials. Though an invader, it also has the rare ability to establish itself permanently in climax vegetation.

Native species also can be expected to invade the plantings. Sagebrush (Artemisia spp.) is known to dominate in disturbed areas, but there is no clear successional pattern here and changes in the herbaceous understory are just as likely with invaders such as cheatgrass (Bromus tectorum), wheatgrass (Agropyron spp.) and needle and thread (Stipa sp.). Other common invaders are russian thistle (Salsola kali), snakeweed (Gutierrezia sarothrae), pigweed (Amaranthus albus), peppergrass (Lepidium perfoliatum), tansy mustard (Descurainia pinnata), tumble weed (Kochia scoparia), tumble mustard (Sisymbrium altissimum) and goosefoot (Chenopodium album).

(h) Fertility Testing

Excavated materials which are not to be treated as fill will be tested for fertility. Based on these tests, an evaluation will be made for possible use of this material as topsoil.

(i) Use of Existing Vegetation

All existing vegetation removed during construction will be evaluated for possible reuse. Such uses might include: 1) transplant stock, either by removal of individual plants or removal of sods; and 2) cover material, using stumps, fallen timber and slash, either in whole form or chipped and spread, as mulch. In addition, for aesthetic reasons and to minimize erosion, every effort will be made to preserve existing vegetation.

(j) Evaluation and Followup

Field personnel in charge of the revegetation project will periodically evaluate species success and plot condition. Evaluation of each site will be made at least once each season after planting. These evaluations will continue until it can be determined that the sites are becoming permanently established.

The most reasonable and practicable way to determine whether or not a given area will support animal populations is to test the available forage on the site by using standard vegetation sampling methods. To determine whether a site is self-perpetuating or becoming self-perpetuating, the evaluation methods will be coupled with vegetation sampling and with information on successional trends gathered during the baseline data collection period. Many years are required for an area of vegetation to complete succession and become dynamically established. The trends toward this dynamic condition, however, may appear early in the sequence of events.

Sites subject to either periodic or unexpected one-time disturbances will be treated to maintain a vegetation cover.

(k) Alternatives to Revegetation

As shown on Figure V-35, it becomes difficult to establish vegetation on slopes greater than 2:1. On areas such as these and on areas where the subsoil is extremely rocky or compacted, it might be appropriate to use treatments other than revegetation. The use of rock cover or the construction of retaining walls are alternate methods which will stabilize the surface and prevent erosion. Rock-covered slopes either can be seeded or left unplanted to allow for natural invasion.

c. Revegetation of the Processed-shale Disposal Pile

The ultimate goals in establishing a permanent vegetative cover on the processed-shale pile are to stablize embankment slopes and produce a vegetative cover which will support fauna of the same kinds and in at least the same numbers as at the time the baseline data were obtained. In addition, the use of primarily native and naturalized species will lessen the aesthetic impact of the disposal embankment by blending it with the surrounding area. In the mid-1960's studies were undertaken on TOSCO II processed shale to determine the feasibility and impact of establishing a vegetative cover on a disposal embankment. For the past ten years, vegetation establishment has been studied in laboratory tests and on small and large-scale field test sites. These studies have demonstrated that processed shale is capable of supporting plant growth and eventually developing a plant cover that is varied, productive and self-sustaining. Following the Colony vegetation establishment studies, methods of implementing a vegetation program on a commercial-scale disposal embankment also have been demonstrated. A listing of the revegetation studies on TOSCO II processed shale is shown in Table V-33.

Processed shale requires special attention during the revegetation process because it has: 1) low fertility due to deficiencies in available nutrients; 2) high soluble salt content; 3) low infiltration rate; and 4) dark color.

The low fertility of the processed shale can be improved by the

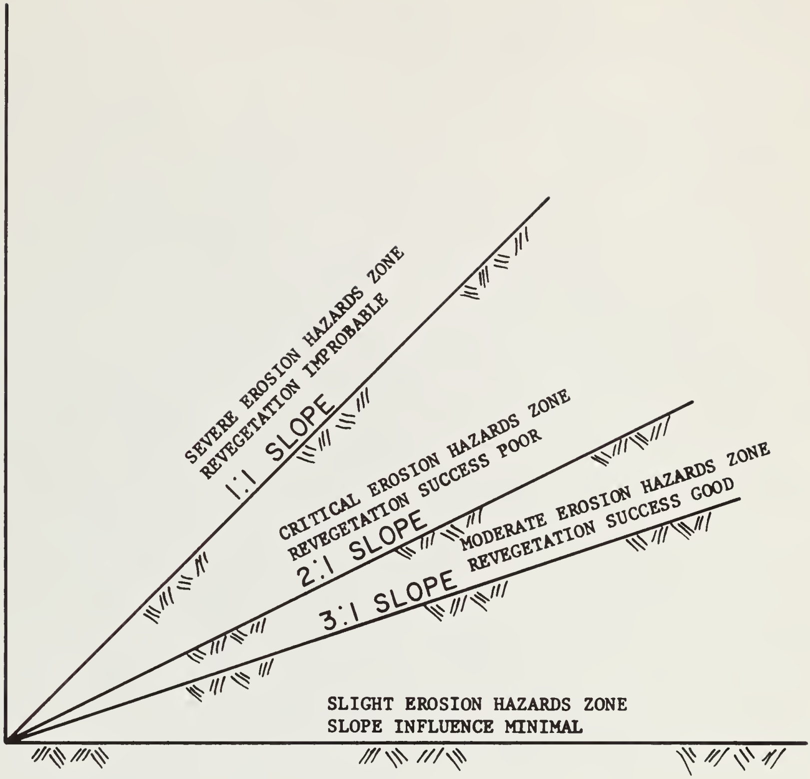


Figure V—35 INFLUENCE OF SLOPE ON REVEGETATION application of fertilizers and, as vegetation becomes established, by the decomposition of plant material in the upper layers of the disposal embankment. Studies to determine the potential for microbial growth within processed shale, and to define the optimum conditions for such growth, are continuing. One means of expediting microbial growth would be to add organic matter (e.g. sewage sludge, ground garbage, manure, etc.) to the processed shale to stimulate microbial activity and aid in the establishment of a nutrient cycle. Tests for available nutrients indicate that processed shale is deficient in nitrogen and phosphorous and low in available potassium. Based on the tests, 600 pounds of phosphorous and 70 pounds of nitrogen per acre should be added initially. Additional applications of nitrogen at this same rate are needed throughout the growing season and during successive growing seasons until the plants are self-sustaining.

Processed shale, similar to native soils, contains a high soluble salt content. The salinity of the processed shale is not an unusual problem in the revegetation process, once the levels of soluble salts have been reduced. Salts are removed by leaching the top 18 inches of processed shale, which is the effective plant root zone. A step-by-step description of the leaching process follows:

- Heavy initial leaching of the processed shale lowers the salt content in the plant root zone, as reported in Colony's "Processed Shale Revegetation Studies, 1965-1973."

- Maintenance watering in the first two years of vegetative establishment continues to leach the salts downward three feet or more.

- Following the first two years, capillary action will cause water and salt migration both upward and downward within the processed-shale pile. Capillary action occurs when water and water-soluble salts move to areas of lesser concentration. The surface of the pile, from which water evaporates, and the unleached subsurface of the pile, which averages 13% moisture, will be subject to capillary migration and salt accumulations as higher concentrations of water develop in the near-surface areas of the pile. A consultant's study on the water pollution potential from the processed-shale disposal pile provided an estimate of water penetration in processed shale. The report states that penetration of rain and snowmelt water into disposal piles is expected to be limited to a maximum of 2.75 feet below the surface during an average precipitation year if the moisture content of the top three feet of the disposal pile averages 13%. Thus, after irrigation, only the top three feet is expected to experience natural precipitation penetration. Each year in the spring, water soluble materials will be leached in the top three feet and later, by capillary action, moved both upward and downward. In native soil, this results in an accumulation of leached material in what is called an alluvial zone. In a disposal pile, the alluvial zone would be located below the 2.75-foot natural precipitation penetration zone. This deposition of salts below the root zone is one force working to lower the total salt content of the plant root zone.

- Salts which accumulate on the surface of the disposal pile due to capillary action will be carried by runoff water into the catchment pond at the base of the pile. The consultant's report suggests that runoff of total dissolved solids will decrease as the pile ages, due to the depletion of soluble salts in the upper portion of the disposal pile.

The reduction of salt content in processed shale by deposition below the root zone and by natural runoff also can be inferred from studies of soils with high salt content and similar texture.

Experience with plots of processed shale with a vegetation cover is even more convincing. No salt toxicity has been noted in Colony's revegetation effort since the plants were established. The Colony report, "Processed Shale Revegetation Studies, 1965-1973," reported good germination and production of cover on the processed shale which had been leached with water prior to planting. Leaching also lowers the pH of the processed shale due to oxidation of sulfides and polythionates. Although the pH of processed shale is high at 7.9 to 8.9, it is similar to the pH range of local soil at 8.4 to 9.0

The structural characteristics of processed shale can be changed to improve infiltration of water through a more friable medium by the addition of organic materials. These also have the added benefits of lowering the pH, lightening the color and raising the level of available nutrients. In experimental plots investigators have used sawdust and peat moss. However, other organic materials such as filter-cake, sewage sludge, manure and ground garbage are preferred because they also stimulate the growth of soil micro-organisms. Assuming this treatment is used, it could require up to 400 tons of filter-cake sewage per month during the last seven years of the disposal operation. This is approximately equivalent to one year's production of solid waste from a city of 15,000 people.

Although color might seem to have little bearing on the success of a revegetation program, the dark color of processed shale causes temperatures at a depth of one-half inch to rise to as high as 140^{o}-150^{o}F. Since temperatures in this range inhibit germination, it is necessary to use some sort of light-colored material to reduce heat absorption. One suitable mulch material for altering color and thereby controlling temperature is straw. Besides being relatively inexpensive and readily available, straw has the additional benefits of holding moisture near the surface of the processed shale for the germinating seeds, reducing the evaporation rate and aiding in the stabilization of the surface. Also, by eventually rotting into the processed shale, it adds organic material.

The 1971 Species Plot in Parachute Creek supports an average of 1500 to 2000 pounds (dry weight/acre) of varied forage (grass, shrubs and trees) on processed shale with no soil cover. This average was established during the period from 1973 to 1975, after irrigation was removed. By way of comparison, Sorghum Gulch produces roughly 600 to 2000 pounds dry weight of natural vegetation per acre, depending on the various sites. Some of these species are poor in palatability.

Revegetation studies still in progress indicate that a six-inch minimum cover of native soil on the disposal embankment would be another aid to establishing a good vegetation cover. Vegetation produced by this method requires less maintenance than a program consisting of direct planting into processed shale. Although it would be necessary to apply a fertilizer to the processed shale before applying the soil cover, the use of the cover would eliminate the problem of high surface temperatures caused by the dark color of processed shale and would also serve to hold moisture at the surface of the embankment. Present studies indicate that a soil cover will retain moisture above the soil-shale interface and provide a longer period of time for water infiltration into the processed shale. Gradual infiltration results in greater reduction of the pH and the soluble salt content of the processed shale. Observations also indicate that there will be little movement of water along the soil-shale interface. A soil cover would also blend in better with the color and texture of the surface of surrounding areas. Properly deposited, it will also reduce the erosion potential of the processed shale. Although using a soil cover may be more expensive than planting directly in the processed shale, it should provide a plant growth medium better suited for the germination and establishment of seedlings of native species. Test plots with a six-inch soil cover produced vegetative growth comparable to test plots with 24 inches of soil cover and with control plots comprised of 100% native soil.

If the soil cover is used, revegetation will proceed as follows: After the initial grading, shaping, contouring and compacting of the processed shale disposal embankment, organic material and fertilizer will be worked into the surface of the embankment to a depth of six to eight inches. Then a six-inch cover of native soil will be spread over the surface of the embankment and an above-ground sprinkler system will be installed. Seeds of the various grasses and forb species which have given good results in the revegetation demonstration plots will be broadcast, watered and nurtured until a cover compatible with the surrounding areas is established. Table V-38 lists data on the performance and palatability of some of the species used in studies to date. Past studies have indicated that certain mixtures of grass, forbs, shrubs and trees provide the best mixture for revegetation of processed shale. Table V-39 contains a tentative list of species for the Tract processed-shale disposal area.

The revegetation plan will use species native to the Piceance Creek basin and as few exotic species (e.g., Russian wildrye, tall wheatgrass,

Table V–38 PALATABILITY AND SUITABILITY OF PLANT SPECIES USED IN REVEGETATION STUDIES

CLASSIFICATION	SCIENTIFIC NAME	COMMON NAME	PALATABILITY*	SUITABILITY
Grasses				
Nat**	Agropyron cristatum	fairway wheatgrass	Good	Good
N(PC)**	A. dasystachyum	thickspike wheatgrass	Fair	Fair
Ex**	A. elongatum	tail wheatgrass	Poor	Very Good
N(PC)	A. riparium (sodar)	sodur streambank wheatgrass	Poor	Good
N(PC)	A. smithii (rosana)	western wheatgrass	Fair	Good
Ex	A. trichophorum	pubescent wheatgrass	Fair	Good
Ex	Bromus inermis	smooth brome	Very Good	Fair
N(PC)	Elymus cinereus	Great Basin wildrye	Fair	Good
Ex	E. junceus	Russian wildrye	Very Good	Very Good
N(PC)	E. salinus	salina wildrye	Poor	Fair
N**	Festuca ovina	hard fescue	Good	Fair
N(PC)	Oryzopsis hymenoides	Indian ricegrass	Fair	Fair
N(PC)	Poa ampla	big bluegrass	Good	Poor
N(PC)	Sporobolus airoides	alkali sacaton	Fair	Very Good
N	S. cryptandrus	sand dropseed	Poor	Fair
N(PC)	Stipa comata	needle-and-thread	Fair	Fair
Forbs				
Ex	Astragalus cicer	sicklepod milkvetch	Good	Poor
Ex	A. falcatus	chickpea milkvetch	Fair	Fair
Ex	Coronilla varia	crownvetch	Good	Poor
N(PC)	Penstemon strictus	Rocky Mountain penstemon	Good	Fair
Shrubs				
N(PC)	Amelanchier utahensis	serviceberry	Good	Poor
N(PC)	Artemisia tridentata	big sagebrush	Good	Good
N(PC)	Atriplex confertifolia	shadscale saltbush	Good	Fair
N(PC)	A. canescens	fourwing saltbush	Very Good	Very Good
N(PC)	A. nuttallii	Nuttall's saltbush	Very Good	Good
N(PC)	Corcocarpus montanus	mountain mahogany	Good	Fair
N(PC)	Chrysothamnus nauseosus	rubber rabbitbrush	Fair	Good
Nat	Eleagnus angustifolia	Russian olive	Poor	Good
N	Kochia vestita	desert molly	Good	Good
N	Purshia glandulosa	desert bitterbrush	Good	Poor
N(PC)	Quercus gambelii	Gambel's oak	Fair	Fair
N(PC)	Rhus trilobota	skunkbush	Poor	Good
N	Robinia neomexicana	New Mexico locust	Fair	Good
N(PC)	Symphoricarpos oreophilus	snowberry	Fair	Good

*Based on A. P. Plummer. (1968). **Nat-Naturalized, N(PC)-Native to Parachute Creek, Ex-Exotic, N-Native to Colorado.

Table V–39 TENTATIVE SPECIES LIST FOR SORGHUM GULCH DISPOSAL AREA

		Species		Drilled Rate (lbs/acre)
Grass:	*	Agropyron cristatum	- crested wheatgrass	2
	*	A. elongatum	- tall wheatgrass	2
	*	A. spicatum var. inerme	- beardless blue bunch wheatgrass	1
	*	A. smithii (rosana)	- western wheatgrass	2
	*	A. intermedium (amur)	- intermediate wheatgrass	1
	*	Bromus marginatus	- mountain brome	1
	*	Elymus cinerus	- Great Basin wildrye	1
	*	E. junceas	- Russian wildrye	1
	*	Festuca ovina	- hard sheep fescue	1
Forbs:	*	Hedysarum boreale (Utah)	- Utah sweetvetch	1/2
	*	Medicago staiva	- alfalfa	1
	*	Melilotus officinalis	- yellow sweetclover	1
	*	Penstemon sp.	- penstemon	1/2
Shrubs:	+	Amelanchier spp.	- serviceberry	
	*+	Artemisia tridentata	- big sagebrush	1/2
	*	Atriplex canescens	- four wing salt brush	2
	*	A. confertifolia	- shadscale	1
	*+	Cercocarpus montanus	- mountain mahogany	1/2
	*	Cowania mexicana	- stansberry cliffrose	1/2
	*	Ceratoides lanata	- winterfat	1/2
	*+	Purshia tridentata	- bitterbrush	1/2
	+	Symphoricarpos oreophilus	- snowberry	
Trees:	+	Juniperus osteosperma	- Utah juniper	
	+	J. scopulorum	- Rocky Mountain juniper	
	+	Pinus edulis	- pinyon pine	
				20 1/2 lbs/acre

* Seed

\+ Transplants at approximately 300 per acre placed selectively in areas of suitability and need.

Rate based on: Plummer, A. Perry, Donald R. Christensen, and Stephen B. Monson, 1968. Restoring big game range in Utah. Utah Div. of Fish and Game, Pub. 68-3.

crested wheatgrass, etc.) as possible. In some instances, exotic species which are already naturalized in the area and which also have proven desirable for revegetation and/or forage may be used.

The revegetation timetable and step-by-step methods to be followed are:

Year 1:

- disposal of the processed shale
- contouring and shaping
- irrigating with 2 to 3 acre-feet of water for leaching
- fertilization of the surface of the processed shale (600 pounds phosphorous/acre, 70 pounds nitrogen/acre, and added organic material, e.g., sewage sludge, sawdust, ground garbage, etc.)
- covering with at least 6 inches of native soil
- drilling the seed into the covering soil
- irrigating with minimum water for germination

Year 2:

- irrigating with 1 acre-foot of water for plant establishment
- transplants planted on the pile
- fertilizing (70 pounds nitrogen/acre)

Year 3-5:

- irrigating if needed (not expected to be necessary)
- fertilizing each year with 70 pounds nitrogen/acre if necessary
- monitoring the plots closely

It is anticipated that the stability and self-sustaining capabilities of the planned vegetation will be high if a proper mixture of native plants (which have been in the Piceance Creek basin for hundreds of years and are therefore suited to this area), naturalized species, and exotic species (which have been proven to grow very well on processed shale) are established on the processed shale.

Vegetative mixtures are preferable to revegetation with a single species. If one species in a mixture does poorly because of an unfavorable site condition or is killed by rodents, insects or disease, one or more of the others may take its place. Another advantage of mixtures is that some species will develop stands quickly to supply forage while the slower-developing species become established. Mixtures also produce vegetation with more varied, and often higher, food value. Plants will be chosen which best supplement native ranges. A variety of species like those in the proposed species list will also provide shelter as well as food for the fauna of the area.

The construction and compaction of the processed shale pile is discussed in Section V. H. The schedule shows that in years 1 through 10 after start-up, 49.5 acres per year would be revegetated; in years 11 through 19, the figure is 21.0 acres per year; and in year 20, 441 acres. This results from the fact that as the pile is built progressively higher, the major part of the final surface is not in place until the later years of the project. Thus, due to the design of the embankment and continued placement of processed shale over the life of the project, the final horizontal surface will not be planted until long after the initial plantings on the lower slopes, possibly as much as 15 to 20 years later.

New information obtained from the continuing studies undertaken by Colony and the Lessee will make it possible to improve methods and to minimize the effort needed to maintain the most suitable vegetation cover. Continued evaluation of the most suitable species and management practices will tend to improve success. Management and monitoring of established vegetation, for example excluding livestock and wildlife from the area being vegetated during the initial establishment phase to reduce stress on the vegetation being established, is also very important.

In the preparation procedures, it will be necessary to remove the native vegetation and usable soil and talus material from the processed-shale disposal area in Sorghum Gulch. Native soil and talus will be removed and stockpiled and maintained for later use as a soil cover for the embankment. Stockpiles which are to be stored for periods exceeding one year will be temporarily vegetated as part of the maintenance program. This will conserve a natural resource (soil) which would be buried if not used. Existing vegetation which is not suitable for transplanting onto the embankment surface may be mixed with the native soil and talus being stockpiled for later use in the revegetation program.

The large areas of the Tract which were chained by the BLM contain large scattered amounts of dead sage, pinyon pine and juniper. Additional plant materials also will be knocked down during future clearing operations. Consideration will be given to utilizing that organic material by grinding, chipping, or otherwise cutting it into small pieces for use as a vegetative soil building mulch in revegetation efforts. It should be noted, however, that such use of brush and vegetation destroys a habitat for birds, small mammals and other forms of wildlife.

Alternatives to the revegetation program, in addition to the plan described above, are:

- no revegetation program and, hence, an uncovered embankment
- use of artificial cover
- establishment of agricultural crops

The first alternative, which involves disposing of the processed shale in a disposal embankment without cover, is considered undesirable because of negative effects on the environment. Without cover, the disposal embankment would present a large area with high erosion potential, both from wind and water.

Along with the high erosion potential, an uncovered disposal embankment also would have a highly negative aesthetic impact due to the dark color of the processed shale in comparison to the much lighter color of the surrounding native soils.

The second alternative, using an artificial cover such as rock, concrete or asphalt to prevent erosion of a disposal embankment, also is considered undesirable because of the poor aesthetics of most of the available materials, both initially and after exposure to the local climate. An artifical cover would be only temporary and would have the additional disadvantage of requiring periodic maintenance or replacement.

The third alternative would be to establish agriculture crops. This type of cover would have the advantages that it could be used by fauna of all kinds and would have a monetary value.

Oil Spill Contingency

Oil Spill Contingency

V. L. Oil and Hazardous Materials Spill Contingency Plan

1. Summary of Potential Spills

2. Summary of Lease Requirements, Applicable Law and Regulations, Definition and Inventory of Oil and Hazardous Materials, and Lessee's Spill Contingency Plan for Oil and Hazardous Materials

   a. Regulatory Requirements
   b. Hazardous Materials Definition
   c. Oil and Hazardous Materials Inventory
   d. Oil Pipeline SPCC Plan
   e. Hazardous-materials Pipeline SPCC Plan
   f. Spill Prevention, Control and Contingency Plan

      (1) Response Plan
      (2) In-plant Spills
      (3) Storm Water Runoff
      (4) Staging Area Spills
      (5) Trucking Spills

V. L. Oil and Hazardous Materials Spill Contingency Plan

The potential for accidental spills or release of oil and other hazardous materials exists as a result of the Lessee's development of the Tract and associated off-tract pipelines and terminals. This plan summarizes the potential source of accidental spills; reviews the current regulations and standards that would apply to the Lessee's activities; defines and inventories the hazardous materials within the plant; and presents the Lessee's spill prevention, control and contingency plans for the plant and associated pipelines.

In addition to the plan described here, the Lessee has prepared other plans which discuss certain aspects of oil and hazardous materials spill prevention and control.

The plans are:

- Air Pollution Control (Section V. A.)
- Water Pollution Control (Section V. B.)
- Fire Prevention and Control (Section V. E.)
- Disposal of Other Wastes (Section V. I.)

1. Summary of Potential Spills

During construction activities, spills of diesel fuels and other fuels and lubricants are possible during transportation, loading and unloading operations, both on-tract and at construction staging areas and rail spurs. Dust suppressants and smaller amounts of miscellaneous chemicals used during construction activities also pose pollution threats if quantities of these materials reach drainages or flowing streams near the Tract.

The on-tract storage of final and intermediate products from the retorting and upgrading of 50,000 barrels per day of shale oil poses the greatest potential spill volume. In the handling of large volumes of hydrocarbons, some small leaks or spills can be expected.

Refinery experiences have shown that large spills usually can be eliminated by proper operating procedures and a careful maintenance program. The use of an oily-water sewer system within the plant complex effectively routes oil spills within the plant to oil separation and recovery units. Storage of raw, partially upgraded and hydrotreated shale oil in large storage tanks also provides the potential for large accidental releases. Proper diking and sizing of storage areas will prevent spills from tanks from reaching flowing streams. By-products such as ammonia and sulfur also pose potential spill problems, but on a much reduced scale since their production volumes are small compared to shale oil.

The pipelining of oil and by-products is another potential source of spills, although pipelines are probably the safest method of transporting large volumes of gases and liquids. Most pipeline leaks result from older pipelines which have undergone corrosion and aging. The shale oil pipeline and by-product pipelines for ammonia a LPG will be new lines and extensive cathodic protection will minimize corrosion of these lines.

The trucking, loading and unloading of hazardous supplies during plant operations as well as the trucking of sulfur by-products from the plant will also be potential sources of accidental spills.

During Phase IV, the potential for volume spills will be greatly reduced and will be limited to such things as fuel and lubricants used during dismantling and restoration activities.

2. Summary of Lease Requirements, Applicable Law and Regulations, Definition and Inventory of Oil and Hazardous Materials, and Lessee's Spill Contingency Plans for Oil and Hazardous Materials

A. Regulatory Requirements

Section 7 of the Stipulations requires that spill contingency plans for oil and other hazardous substances be submitted with the DDP and that these plans conform to the National Oil Hazardous Substances Pollution Contingency Plan, 36 FR 16265, August 20, 1971, as amended. The national plan was developed by the Council on Environmental Quality in compliance with the Federal Water Pollution Control Act, 33 USC 1251. It has since been amended on September 9, 1972 (37 FR 18411), and December 21, 1972 (38 FR 2808). Because the federal government has vested jurisdiction of Spill Prevention Control and Countermeasure (SPCC) plans in the U. S. Department of Transportation (U. S. Coast Guard) for transportation-related facilities, and in the Environmental Protection Agency (EPA) for non-transportation related facilities, the Lessee will have prepared and will implement such SPCC plans at the time operations commence in accordance with the regulations of the U. S. Coast Guard (USCG) and EPA. These plans will be submitted to the AOSS after engineering design has been completed. A brief summary of the jurisdictional aspects of SPCC plans is presented below.

Spill regulations fall into two classes: 1) oil, and 2) other hazardous substances. Regulations concerning oil spills have been extensively developed and codified. Federal government jurisdiction has been split between the EPA and the U. S. Coast Guard (USCG), with EPA originally designated as responsible for inland waters and USCG for coastal waters and ports. A subsequent memorandum of understanding between the Secretary of Transportation and the Administrator of the EPA (FR Doc. 73-25448, December 10, 1973) assigned responsibility for all "transportation-related onshore and offshore facilities," including pipelines, to the USCG. In 39 FR 41989, December 4, 1974, the USCG extended its jurisdiction to the "entire riverine system, extending upstream to the sources," thus clearly encompassing inland pipeline spills which result in water pollution. The EPA has published (38 FR 237-34164, December 11, 1973) regulations and guidelines requiring that owners of non-transportation-related facilities, which could conceivably spill oil into the waters of the nation, prepare and implement a (SPCC) plan within six months after a facility first commences operation. The USCG has not yet made mandatory such a requirement for transportation-related facilities.

For administrative purposes, oil spills in inland waters are classified (38 FR 21889) as minor if they range from 1000 to 10,000 gallons and major if over 10,000 gallons. Discharge of hazardous substances in a "harmful quantity" has not yet been defined, but the definition would have to be related to the size of the stream or body of water involved, velocity of flow or diffusion, toxic concentration, etc. Discharges of oil or hazardous substances that either generate critical public concern or pose a substantial threat to public health or welfare are classified herein as major regardless of the quantities involved.

Because of the as-yet undetermined nature of hazardous materials definitions and regulations, it will be assumed for the purposes of this spill plan that:

- any and all chemicals not obviously oils will be classified as hazardous materials
- any release of such materials to a waterway will be assumed harmful and require corrective action
- required elements for a hazardous materials SPCC plan will be the same as for oils

b. Hazardous Materials Definitions

Regulations comparable to those requiring an SPCC plan for potential spills of oil have not yet been developed for the control of pollution by spills of hazardous materials other than oil. EPA has taken the first step by proposing a tentative list of hazardous materials (39 FR 30466, August 22, 1974, "Designation and Determination of Removability of Hazardous Substances from Water").

In 39 FR 30466, EPA has proposed certain criteria for placing a material in the hazardous classification for water pollution. The Federal Water Pollution Control Act provides that such a classification be developed for "such elements and compounds which, when discharged in any quantity into or upon the navigable waters of the United States or adjoining shorelines or the waters of the contiguous zone, present an imminent and substantial danger to the public health or welfare, including but not limited to fish, shellfish, wildlife, shorelines and beaches." The proposed criteria include an element or compound produced in excess of research quantities. Such elements or compounds possess sufficient danger potential to be considered as a candidate hazardous substance if it is lethal to: 1) one-half of a test population of aquatic animals in 96 hours or less at a concentration of 500 milligrams per liter (mg/l) or less; 2) one-half of a test population of animals in 14 days or less when administered as a single oral dose equal to or less than 50 milligrams per kilogram (mg/kg) of body weight; 3) one-half of a test population of animals in 14 days or less when dermally exposed to an amount equal to or less than 200 mg/kg body weight for 24 hours; 4) one-half of a test population of animals in 14 days or less when exposed to a vapor concentration equal to or less than 200 cubic centimeters per cubic meter (volume/volume) in air for one hour; or 5) aquatic flora as measured by a 50-percent decrease in cell count, biomass or photosynthetic ability in 14 days or less at concentrations equal to or less than 100 mg/l.

To be further considered for designation as a hazardous substance, any element or compound meeting the above criteria must have a reasonable potential for being discharged, i.e., spilled into a water body. Factors being considered in making this evaluation include the production quantities, modes of transportation, handling and storing practices, past spill experiences and physical-chemical properties of each substance.

Two types of "spills" are being considered. The first relates to incidents occurring during transportation, storage and use in which there is normally no release of substance except during a spill. The second relates to industrial production facilities in which a designated hazardous substance is normally released in permitted quantities in an effluent stream governed by an NPDES permit. An increase in effluent concentration above the permitted level would be classified as a hazardous spill.

c. Oil and Hazardous Materials Inventory

A list of substances expected to be present in substantial quantities within the shale oil plant is presented below. The list identifies the materials and maximum storage capacity of each material to be stored both on and off-tract which would be classed as pollutants if allowed to escape. The list does not include an evaluation of the possibility of such an occurence.

Material Stored	Storage Capacity BBL
On-tract	
Coker Feed	110,000
Gas Oil Hydrotreater Feed	480,000
Naphtha Hydrotreater Feed	260,000
Foul-water Stripper Feed	100,000
Gas Oil Hydrotreater Product	155,000

Material Stored	Storage Capacity BBL
Naphtha Hydrotreater Product	110,000
No. 2 Diesel Fuel	4,000
Plant Fuel Oil	100
Butane	3,000
Oil-water Separator Liquid	2,000
LPG	4,000
Ammonia	2,800
Sulfur	1,500
Off-tract Terminal	
LPG	20,000
Ammonia	6,600
Sulfur	20,000 (3,000 long tons)

Storage capacities shown are for net contents and do not include allowances for heel or vapor space. These capacities are based on production of 50,000 barrels per day of shale oil. Higher or lower production rates would modify tank capacities accordingly.

In addition to the stored materials, certain other materials and liquid streams may be present which could also be classed as potential pollutants if the materials escaped. Examples of such materials include foul water which contains ammonia and various catalysts and miscellaneous chemicals. A more detailed description of these materials is presented in Section V. I., Disposal of Other Wastes.

d. Oil Pipeline SPCC Plan

One potential for water pollution by accidental spills is the product oil pipeline. Although not a mandatory USCG requirement for pipelines, an oil spill contingency and response plan for the proposed 195-mile-long La Sal product oil pipeline has been prepared as part of Colony's Environmental Impact Analysis. An SPCC plan of essentially identical scope will be prepared for all product pipelines connecting with the Tract, upon completion of final selection of the specific route and design of the pipeline. The submittal of a plan containing the in-depth technical details for the C-b product spur line is not feasible at this time. However, those portions of the Colony plan relating to discovery and notification, response action, general containment and countermeasures, cleanup and removal, surface cleanup and restoration, disposal of recovered oil and associated materials, post-cleanup, organization, and material requirements, surveillance and communication, special programs, safety and training will be employed by the Lessee on the C-b Shale Oil Project. A brief summary of the Colony plan follows.

The containment and countermeasure procedures established for the La Sal pipeline will emphasize, in areas other than where preconstructed diking systems are employed, bringing trained men and equipment to the scene as quickly as possible to analyze spills and initiate the established correction procedures. The route chosen for that pipeline is such that containment and cleanup of any oil spill would most likely be on land. However, as the pipeline does cross the Colorado River, both land and water containment procedures must be considered.

Although each potential oil spill location would call for individual consideration of techniques to be employed, the general methods described below are applicable to the overall system and route.

Source Control. On-scene source control will be critical. The source control procedure involves closing of manual valves and immediate repair, permanent or temporary, of the damaged or malfunctioning equipment.

Control of the Spread of Oil. Varying physical conditions require a wide variety of methods and equipment to control spreading oil. In addition, the time lag involved for arrival of men and equipment will affect the type of control methods to be used. Surveillance and communication will be critical to the effective control of the spread of oil.

The general technique used to control the spread of oil involves constructing dikes or diversion ditches, employing booms or barriers (when the oil spill has reached water), use of absorbents (such as straw, usable on both land and water) and the use of chemicals to disperse or coalesce the oil on water (restricted by regulation). If the release of oil is necessary to make repairs on the system, temporary ponds or mobile containers will be utilized to hold any oil released.

The La Sal plan also contains extensive cleanup and removal procedures. The basic components of these procedures include collection and recovery of oil and contaminated debris, removal of soil and vegetation, and cleanup of the affected area.

e. Hazardous-materials Pipeline SPCC Plan

The hazardous-materials pipelines would carry ammonia and propane. The spill contingency plan for these pipelines will be similar to that described above for the oil pipeline, with the major difference being that the material passing through these pipelines will gasify when exposed to the ambient air, and will not spill out as a liquid. For this reason, the control measures to be undertaken in the case of a pipeline malfunction or damage will consist primarily of shutting off the valves nearest to the damaged area, much as the control measures used with a natural-gas pipeline. No confinement techniques will be needed.

Detection of leaks from the pipeline will be by visual observation and pressure monitors on the pipeline. Any leakage will be apparent from the frosting up of the pipeline and surrounding area.

Cleanup and disposal measures generally will not be needed due to the gaseous form of the material. The gas will escape to the atmosphere. This presents the additional threat of the potential for combustion of the gases while concentrated in the area. Special procedures will be taken to ensure that no flames are present in the area following a leak, and the use of any motorized vehicles will be minimized. Following closing of the valves above the leak, the area will be restricted for enough time for the gases to disperse.

f. Spill Prevention, Control and Contingency Plan

(1) Response Plan

Basic requirements of acceptable SPCC plans, which are conventional and universally used in refineries and pipelines, include such information as the name and location of the facility and names of responsible personnel, storage or handling capacities and daily through-put, storm water runoff capability, facility description with flow diagram and topographical maps, analyses of risks, and preventive or corrective measures to be taken. Much of this information will not be available until a detailed engineering design of the facility has been completed. The SPCC plan set forth here is descriptive in nature of the present plans, and is subject to modification as becomes necessary before the facility goes into operation. The SPCC plan will become effective at the time of start-up of the plant. The SPCC plan will be reviewed and certified by a registered professional engineer. A copy of the plan will be maintained at the plant and will be available for review by authorized parties.

Notification. In the event of an accidental spill of oil or other hazardous material reaching or having the potential of reaching a waterway, various government entities must be notified. Activation of regional or national spill response teams may then be initiated as required according to the respective regional or national spill contingency plans. Spills occurring on or in the immediate vicinity of the tract would require the following notifications:

Environmental Protection Agency
Region VIII
Denver, Colorado
303 837-3880

Colorado Department of Health
Water Quality Control Division
Denver, Colorado
303 388-6111, Ext. 231
303 366-5363

Pipeline or transportation-related spills would also be reported to:

U. S. Coast Guard, 2nd District
St. Louis, Missouri
314 622-4614

If a spill occurs in surface waters with a possibility of harm to fish or other wildlife, notification would be made to:

Colorado Division of Wildlife
Denver, Colorado
303 825-1191

If contamination of public water supplies is possible, notification would be made to:

Engineering & Sanitation Division
Colorado Department of Health
Denver, Colorado
303 388-6111, Ext. 322

If it is necessary to move a large number of vehicles or to control traffic at any location, notification would be made to:

Colorado Highway Department
State Patrol
Denver, Colorado
303 757-9011, Ext. 401

All spills would be reported to the office of the AOSS. Other government agencies to be notified in certain cases include:

Bureau of Land Management
Grand Junction District
303 242-8515

Bureau of Land Management
455 Emerson Street
Craig, Colorado
303 823-3289

U.S. Forest Service
Denver, Colorado
303 233-6186

Local city, fire, police and health departments

Spill Response Team. All spills not involving the product oil pipeline will be responded to by an in-plant spill response team which will be especially organized and trained for this purpose. A Spill Response Coordinator (SRC) will have the primary responsibility for deciding the action required and assembling the necessary team elements. A designated SRC will be available at all times.

When a spill or indication thereof is first observed by plant personnel it will be reported through the operations control center and the dispatcher will then contact the SRC directly. The magnitude of the spill or the sensitivity of the area in which the spill occurs will determine the reporting procedure to be followed and the participating units required. If a spill should be reported first by an outside observer, the switchboard operator receiving the report would transfer the call directly to the SRC, if possible.

For a small spill, where cleanup will be routine and natural entrapment has already occurred, cleanup activities may be handled within the operating department where the spill occurred and the SRC will not call upon other members of the spill team. If a large spill occurs, then more people will become involved. Definitions of some team responsibilities follow.

The SRC has the overall management responsibility for all activities related to safe control, containment, cleanup and mitigation of the environmental effects of any spill, along with the necessary restoration of facilities, liaison with governmental agencies and public relations.

The Cleanup Coordinator has the responsibility to study and review cleanup activities from past spills, both large and small, to be constantly aware of new developments in cleanup methods equipment and materials, and to have an in-depth knowledge of the behavior of oil and other hazardous materials when spilled.

The Government Liaison Coordinator has the responsibility for liaison with federal, state and local enforcement agencies, both before and during spills.

The Public Relations Coordinator has the responsibility for presenting accurate and factual information to the public during a major environmental incident.

The Legal Coordinator has the responsibility to ensure that all contracts and agreements with outside cleanup contractors are in sound legal form and in compliance with applicable laws, rules and regulations, and to coordinate the activities of insurance representatives.

The Environmental Protection Coordinator has the responsibility to ensure that all containment, cleanup, restoration, wildlife rehabilitation and other activities are conducted in an environmentally sound manner. He will coordinate with the environmental investigators from government agencies.

The Procurement and Logistics Coordinator has the responsibility for procurement of company-furnished personnel, equipment and material to provide logistical support necessary at the scene.

The Documentation Coordinator has the responsibility to ensure that all aspects of activities are properly documented and recorded, both in writing and visually (photographs, movies, maps).

The Accounting Coordinator has the responsibility to ensure that all aspects of financial activities are properly handled, documented and recorded.

Coordinators for other activities also may be required, such as a technical evaluator for new equipment, or coordinators for safety and security, food and housing, fire-damage control and emergency services.

Formal training sessions will be held for all personnel with supervisory or staff responsibilities for spill response and cleanup. The key elements of these training sessions will involve:

- a printed organization chart of the response team showing all job titles
- a formal and detailed description of each job
- a series of seminars for each job, including operation of actual cleanup equipment, radios, etc., where appropriate
- a periodic refresher and updating session, perhaps on a yearly schedule.

(2) In-plant Spills

Prevention. The first step in preventing accidental spills is to analyze the potential which exists. The objective of such an analysis is to identify facility weaknesses and to make engineering modifications which can significantly raise the level of spill prevention in the overall facility design. Statistics show that about 88% of facility spills are the result of operator error, 10% are due to mechanical failure and 2% to all other causes. Thus, the area having the greatest possibilities for improvement is increased operator reliability.

Operator reliability will be stressed when training new personnel who will be involved with transferring materials in the plant. Operating procedures for prevention of conditions and incidents leading to spills will be periodically reviewed. Another method of increasing operator reliability is through the use of additional warning and monitoring systems within the plant such as level alarms, back-flow indicators, etc. An external human factor is the possibility of vandalism such as the opening of valves, etc. Within the plant proper, with large numbers of employees present at all hours, the risks of vandalism should be relatively remote. At any outlying locations where unattended tanks or pipeline valves might be located, extra security precautions (fences, lights, regular patrols and locks) may be justified.

The overall design of the proposed oil shale processing complex will be unusually resistant to accidental spills which could have a significantly harmful effect on the environment. All large tanks will be diked to provide first-order protection in case of tank failure, accidental over-filling, etc. The dikes and all other liquid-containing systems will be designed to American Petroleum Institute standards as described in API Bulletin D16, First Edition, March 1974, and will be conventional structures of the type used in refineries. The methods and results of their use is widely known and accepted. In addition, all storm drainage from the plant, as well as the dikes, will be diverted to the Sorghum Gulch catchment dam. Thus, a failure in the primary dike containment system would not result in a spill reaching a waterway. It is possible that, due to topography or other considerations, the final plant design will result in some tanks or structures which cannot drain to Sorghum Gulch. In that case, a dike failure in combination with a spill (harmful spills almost always result from a combination of unlikely events) could result in a pollution threat. Such design situations will receive a thorough pre-construction analysis to minimize the level of risk and to provide additional mechanical safeguards and alarms where warranted.

Detection. Because the plant site will be continuously manned, visual observation will result in the detection of leaks and spills at the earliest possible time.

Confinement. If at all possible, spills will be prevented from reaching the Sorghum Gulch reservoir. Neutralization, recovery, etc., is much more efficient if the material involved can be maintained in its original state of concentration.

For small spills of toxic or hazardous material, temporary containment techniques have been developed by EPA using foam-in-place plastic to build dams and barriers. Dispensing kits for the plastic foam will be located at convenient, well-marked locations throughout the plant. Instructions in their use will be provided for employees in each shift crew.

Cleanup and Disposal. Since no in-plant spills are expected to breach either the plant boundaries or the Sorghum Gulch reservoirs, cleanup will be relatively simple. In most cases, any spilled material can probably be pumped directly from the dike or other containment area directly back to the original source. If the material is contaminated to such an extent that it must be disposed of, it will probably be pumped first to a temporary holding tank and then picked up by a commercial waste disposal firm. Similar plans will be prepared and implemented for any other oil or hazardous substance storage areas.

(3) Storm Water Runoff

When sufficient rain water or runoff has collected in a containment or storage area to require discharging, the surface of the water will be visually inspected for any film, sheen or discoloration due to the presence of oil. If oil is present, equipment will be brought in to separate out the oil. Sealed valves will be opened to let the storm water escape to storm drains or open water courses only when the runoff waters are oil-free. No valves will be opened to allow escape of storm water runoff until such action is authorized by a supervisor, and this authorization will be granted only when inspection of the surface of the water indicates no oil is present.

(4) Staging Area Spills

Prevention. Loading and unloading procedures will meet the minimum requirements and regulations established by the U. S. Department of Transportation. Warning signs will be prominently displayed in the area, warning of the presence and loading of oil or hazardous material. Tank cars or trucks will have brakes set, motors off, and wheels blocked where possible, and will not be moved at any time during the loading procedure. If any spill or leak occurs, all traffic in the area will be stopped immediately.

Detection. Drivers, engineers, loaders and others in the area at the time of loading of any oil or hazardous material in the staging area will be required to maintain constant surveillance for any sign of a spill or leakage of any material. Human observation shall be the basis for detection of any spill.

Confinement. Any potential spill of oil or other hazardous material in the staging area is expected to be very small in quantity. Small dikes or diversion facilities are expected to be constructed in the staging area, which will hold the maximum capacity of any single compartment of a tank or truck in the area. In addition to foam-in-place containment techniques, the regular spill confinement equipment located at the plant will be used in the case of a spill at the staging area.

Cleanup and Disposal. Equipment and trained personnel located at the plant site to clean up and dispose of oil spills will also be available at all times for use at the staging area.

(5) Trucking Spills

Prevention. During all loading operations, warning signs or other communication will be prominently displayed. Drivers will be required to set the trucks' brakes, shut off the motor wheels, and get out of the trucks during loading. Trucks may not be moved until the loading operation is completed and the filling nozzle is removed from the truck and replaced in its rack. All drains and outlets from the trucks will be checked for leakage before, during and after loading. If a spill or leak is detected, all truck traffic in the area will be stopped immediately.

Detection. Drivers, loaders and other persons in the loading area will be required to watch for any sign of leakage or spillage. Detection will be assured through constant human surveillance.

Confinement, Cleanup and Disposal. Except for an extraordinary accident, any oil spill from a truck will probably be very small and located exclusively on land. These small spills will be contained and cleaned up with the portable equipment stored at the plant site. In addition, small man-made dikes or diversion ditches can be constructed in areas away from the plant to prevent the spread of a spill. Absorbents could also be utilized to confine and clean up the spill. Disposal would be carried out by loading the oil or contaminated debris and absorbents into trucks for hauling back to the plant disposal site.

No truck-related oil spills are expected to reach water sources. However, were this to happen, equipment and trained personnel from the plant site would be immediately brought to the site to confine, clean up and dispose of the oil, utilizing booms, barriers, separators and absorbents. Chemicals and dispersants would be used only as a last resort.

Off-Tract Corridors

Off-Tract Corridors

V. M. Off-tract Corridors

1. Proposed Activities

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Compliance

   a. Corridor Routes
   b. Environmental Protection

M. Off-tract Corridors

The development of the Tract for a commercial shale oil project will require the transportation of personnel, material, products and services to and from the Tract from a variety of geographic locations. This Corridor Plan was developed with the objectives of minimizing environmental harm and generally providing sound planning for off-site activity. These objectives are best met by the use of multiple-purpose corridors when feasible. In addition to the plans set forth here, the Lessee has prepared other plans which deal with both access and service corridor plans but are not repeated in this section. These plans include:

- Water Pollution Control (Section V. B.)
- Protection of Objects of Historic and Scientific Interest and Aesthetic Values (Section V. D.)
- Fish and Wildlife Management Plan (Section V. J.)
- Erosion Control and Surface Rehabilitation Plan (Section V. K.)
- Oil and Hazardous Materials Spill Contingency Plan (Section V. L.)

1. Proposed Activities

In connection with the Phase I development of the Tract, the Lessee will require road access to and from the Tract for personnel, equipment and materials. Phase I activities also necessitate the construction of communication and electrical power supply facilities to the Tract.

Phase II construction work will include the building of water, LPG, ammonia and shale oil product pipelines. Although the use of unit trains has been considered as a possible alternative to pipelining, construction of a rail line to the Tract does not appear to afford any economic or environmental advantages.

Phase III operations will make continuous use of corridors during the operating life of the plant.

2. Summary of Lease Requirements, Applicable Law and Regulations and Lessee's Plan for Compliance

Section 2(A) of the Stipulations requires that the Lessee provide corridor plans for roads, pipelines and utilities for approval by the AOSS. Each plan will include probable major design features and plans for protection of the environment. The Lessee will make use of multi-use corridors for roads, pipelines and utilities as practicable.

a. Corridor Routes

Studies have been conducted to determine the best routing and multi-use potential for service corridors to and from the Tract. Although the majority of the studies have been on routing the shale oil product pipeline from the plant to a link with a common-carrier oil pipeline, investigations also have been conducted on water pipelines, by-product pipelines, power and communication lines, railroads and roads.

The by-product and shale oil product pipeline corridor studies were based on extensive studies conducted and published by Colony Development Operation. The major results of the studies have been reported in Colony's "An Environmental Impact Analysis for a Shale Oil Complex at Parachute Creek, Colorado, Part II - Pipeline." The Colony product pipeline studies included various routes: northeast to Merino, Colorado; north to Casper, Wyoming; and southwest to Aneth, Utah.

The northeast and southwest corridor studies were divided into two phases. In the first phase, all potential northeast and southwest routes were studied and described in general terms. Three routes were then chosen for detailed ecological reconnaissance in the second phase. The first and second phase corridor routes studied are shown in Figures V-36 and V-37.

General reconnaissance, a continuous vegetation survey along potential corridors, and quantitative ecosystem sampling were used as a basis for analysis and conclusions. The information gathered was used to select the corridor which would have the least impact on the environment, considering both short-term and long-range effects.

Of the three corridors, the corridor selected follows a southwesterly route designated as the "Moab Route" on Figure V-36. The line would connect to an existing pipeline system at Aneth, Utah.

A pipeline route from the Tract to a connection with the Colony pipeline described above was studied as part of a multi-purpose corridor which would carry water, shale oil, by-products (liquid petroleum gas and ammonia) and possibly a road. This multi-purpose corridor would extend southward about 11 miles from the Tract, along Scandard Ridge to the drainage divide, where it would join the Colony pipeline corridor (Figure V-38). The actual surface disturbance will be a strip up to 50 feet wide, except in areas specifically designated as environmentally sensitive. An environmental study was conducted over an area including the land 200 feet on either side of the centerline. The environmental setting in the corridor is described in Section XIV.

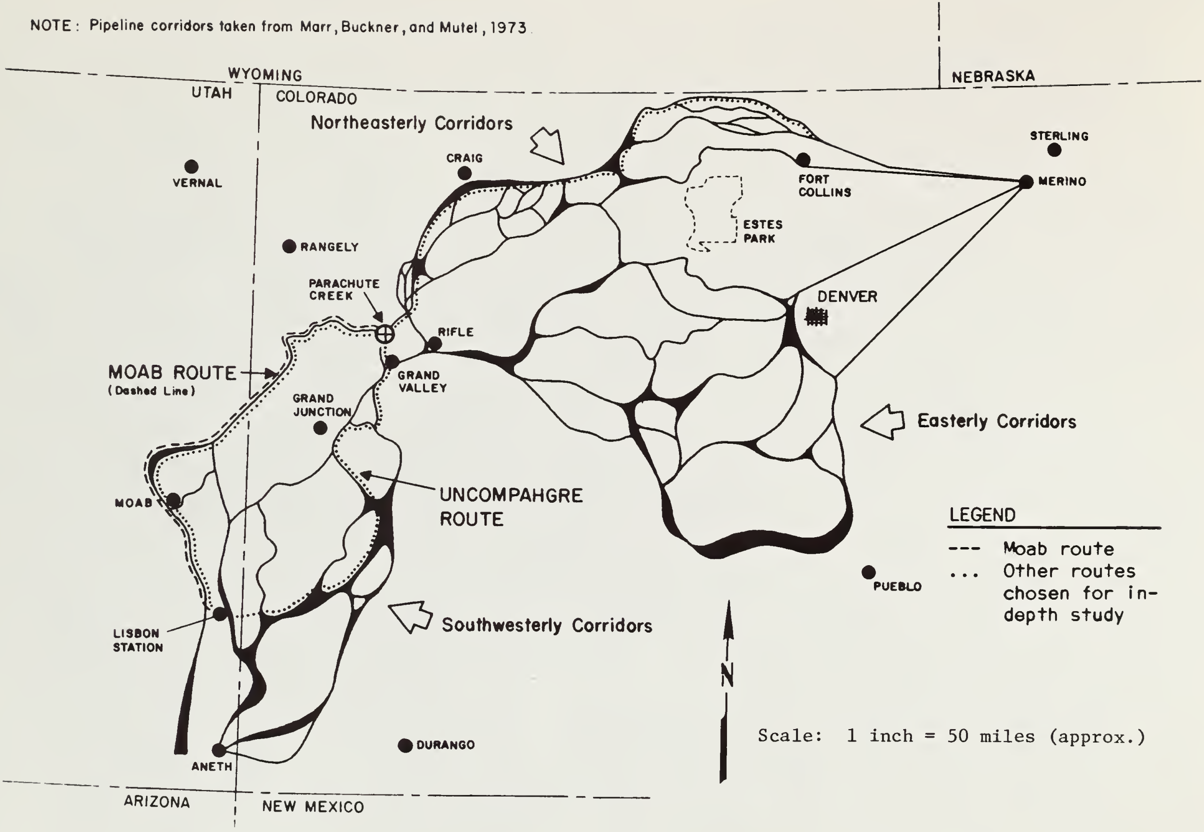


Figure V–36 ALTERNATIVE PIPELINE CORRIDORS

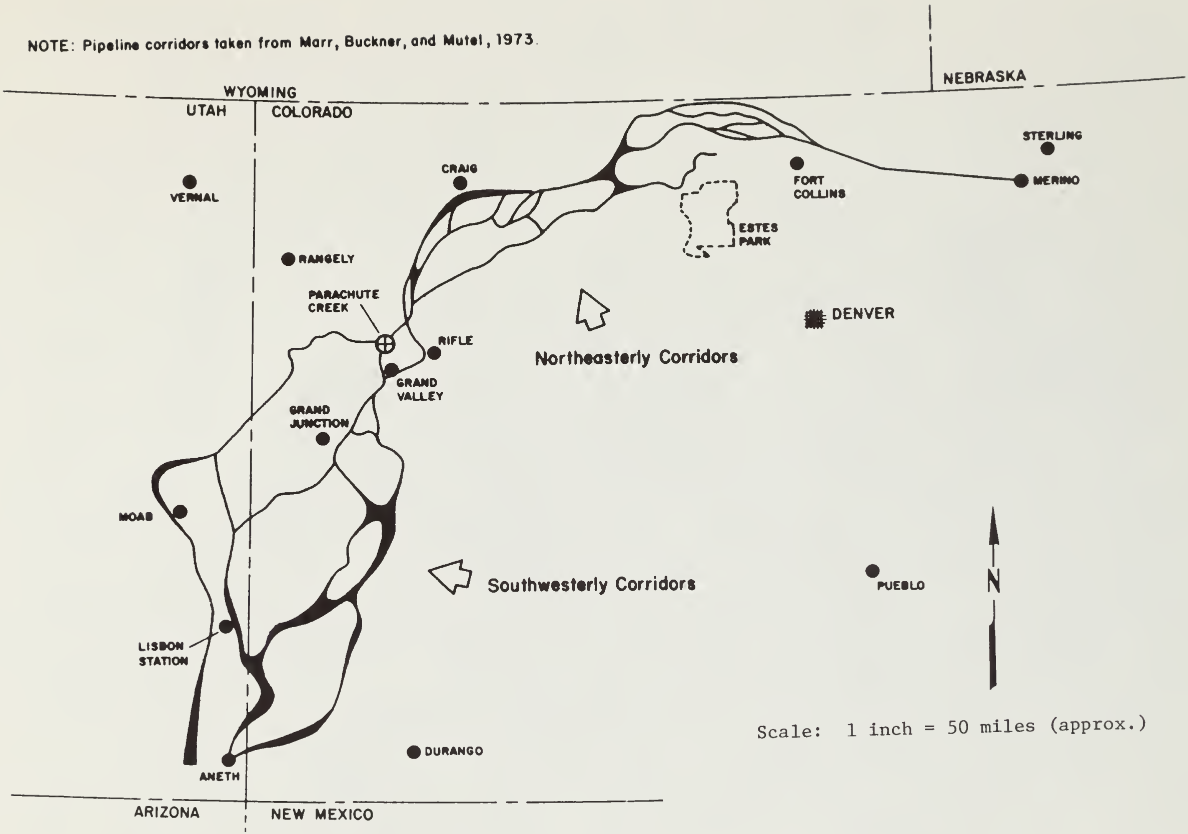


Figure V—37 PIPELINE CORRIDORS

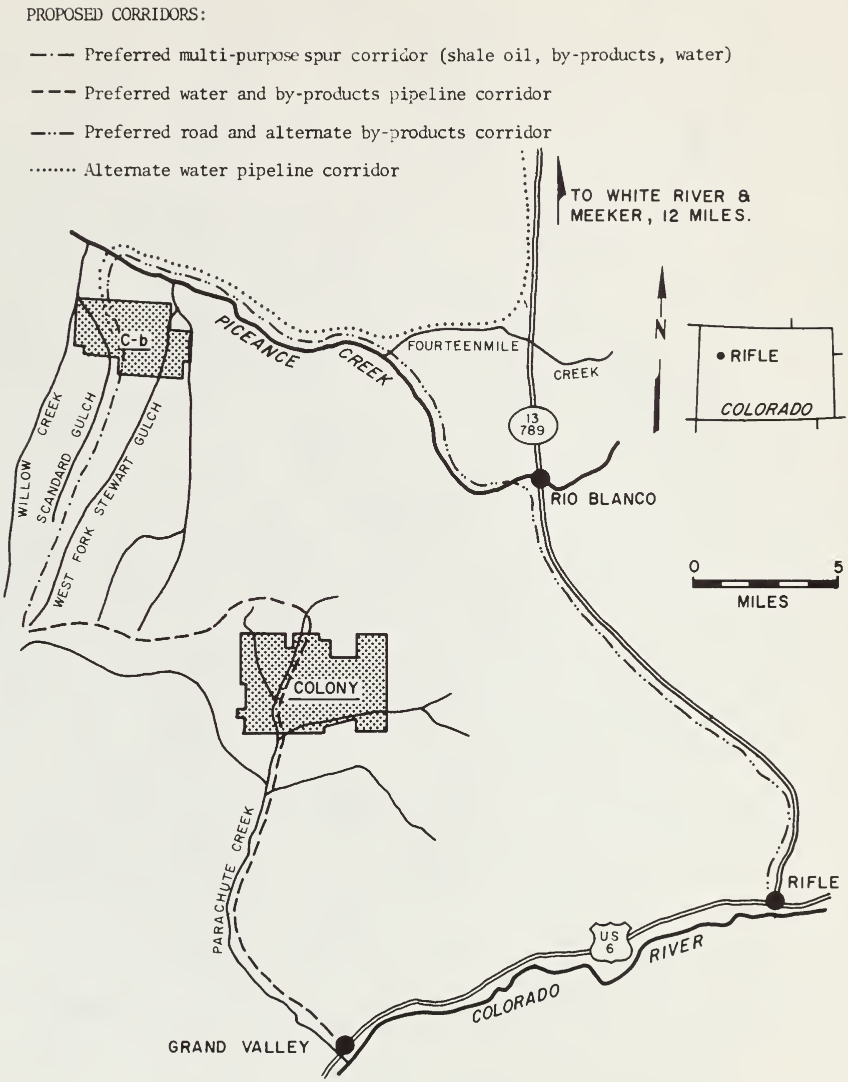


Figure V—38 CORRIDOR STUDY AREA

While the preferred pipeline for by-products would be via the multi-purpose spur to the Colony plant and then south to terminal facilities at Grand Valley, an alternative would be to truck by-products to an off-tract staging area which has rail service. This route would use the Piceance Creek road.

Two options are available for delivering surface water to the Tract, as previously noted in Section II. C. One possibility would be to acquire water from the Colorado River. In this case water would be diverted at Grand Valley and pumped up Parachute Creek to the Roan Plateau, and then piped to the Tract via the multi-purpose spur. An alternative would be to divert water from the White River at or above Meeker and pipe it to the south, up Sheep Creek to Fourteenmile Creek, and then down Fourteenmile Creek to Piceance Creek and the Tract.

The selection of the powerline corridors to the Tract will be the responsibility of the public utility providing service to the area. The location of the powerline corridors will be contingent upon the situation prevailing at the time firm contracts are negotiated. Before final routes can be determined, the location and size of equipment already in service, the projected needs of other customers, and the power requirement of the Tract must be evaluated. Depending upon the situation, a master power system might be developed which would furnish electrical energy to all the oil shale developments in the basin.

It is anticipated that power will be brought to the Tract in two stages. The first stage would be for the Phase I developmental mining. Depending upon a final determination of the power requirements of the developmental mining, it may be possible to extend existing lines along Piceance Creek about five miles south to the Tract (Figure V-39). However, if this power supply is inadequate, it will be necessary to bring in outside power. The most probable route at this time would be a line extending south from existing lines along the White River, as shown on Figure V-39.

Additional power will be required in the full commercialization of the Tract during Phases II and III. In order to avoid plant shut-down in the event of power failure, two separate power sources will be needed. It is anticipated that the line brought to the Tract for Phase I development mining would be upgraded to provide one power source. The route of a second source cannot be predicted at present. It could be from a master system or it might be from a source paralleling the Meeker-Rifle road. A possible route from an eastern source to the Tract is shown on Figure V-39.

Although the final plant communication system has not been designed, it is anticipated that a buried telecommunication duct may be installed within the main corridor from the Tract to Grand Valley. This duct would probably be on the order of a six-inch, or nine-inch, concrete conduit. An alternate communication system such as microwave

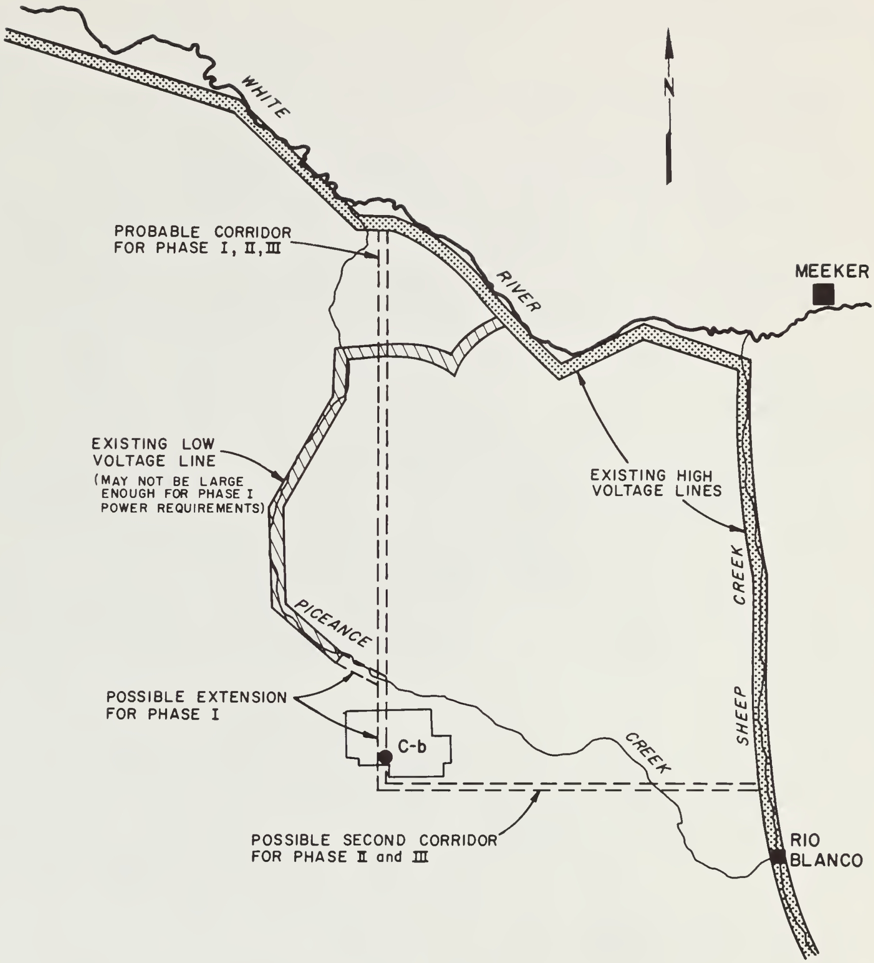


Figure V–39 POSSIBLE POWER LINE CORRIDORS may be installed. It would require construction of a large radio tower on the Tract. In the event a master telephone system could be developed to serve the needs of one or more additional oil shale projects in the basin, consideration would be given to the use of this facility, depending upon location and time of construction.

The preferred road corridor to the Tract would use existing roads. It would extend northward from Rifle 22 miles along State Highway 13/789 to the Rio Blanco, Store, then 17 miles westward on Piceance Creek road, and then south 2 miles to the Tract. Because of the necessity of transporting heavy loads and increased traffic, substantial upgrading of these roads will be required.

An alternate route, not presently favored, would use existing roads from Grand Valley up Parachute Creek to the Colony site. Then from the Colony site a new road would be required across the Plateau to the Tract. Although this route would have the possible advantage of sharing the pipeline corridor, the Battlement community, a staging area and a common railroad spur with Colony, several miles of new road would be required through difficult terrain over public and private land. Possible timing conflicts with the Colony project, and the possibility the route would suffer traffic congestion, are additional disadvantages.

b. Environmental Protection

Environmental protection measures for construction and operation of the pipelines include construction practices, spill measures, shut-off valves, emergency procedures, cathodic protection, insulation and corrosion protection, waste disposal and cleanup, hydrostatic testing, maintanence and leak detection. These are discussed in detail in Section II. C. and Section V. L., Oil and Hazardous Materials Spill Contingency Plan. Section II. C. also describes the ditching and backfilling procedure that will be followed to minimize erosion and protect normal drainage routes. In accordance with recommendations in the scenic evaluation of the corridor, attempts will be made to "ruffle" the edge of the right of way to minimize visual impact of the corridor. In addition, attempts will be made where practical to replant some of the shrubs and to save trees. Erosion control and rehabilitation of land in the pipeline corridor will be carried out as described in Section V. K., Erosion Control and Surface Rehabilitation Plan.

Preliminary investigations of the several powerline corridors under consideration indicate that a combination of conventional and helicopter construction techniques will be required to complete the proposed construction in accordance with good environmental practices. Where temporary construction roads are necessary, they will be located, built and rehabilitated in an environmentally acceptable manner as described in Section II. D. 11. Existing roads and trails will be used where feasible. Power transmission facilities will be designed and constructed in accordance with the guidelines set forth in "Environmental Criteria for Electric Transmission System" (USDIA, USDA, 1970). Distribution lines will be designed and constructed in accordance with REA Bulletin 61-10 (Powerline Contacts by Eagles and other Large Birds).

VI Monitoring Programs

VI. Monitoring Programs

VI. Environmental Monitoring Programs

A. Introduction

Section 1 (C) of the Stipulations requires the Lessee to conduct Baseline Programs for two consecutive years and thereafter to conduct Monitoring Programs to measure perceptible changes from the baseline conditions. The description of the baseline studies and the first year's results are set forth in Volume II. This Section VI of the DDP describes the Monitoring Programs which Lessee proposes to carry out during the construction and operation phases of the project following completion of the second year of Baseline Programs.

The purposes of the environmental Monitoring Programs, as defined in Section 1 (C) of the Stipulations are to provide: 1) a record of changes from conditions existing prior to development operations, as established by the collection of baseline data; 2) a continuing check on compliance with the provisions of the Lease and Stipulations, and all applicable federal, state and local environmental protection and pollution control requirements; 3) timely notice of detrimental effects and conditions requiring correction; and 4) a factual basis for revision or amendment of the Stipulations.

The achievement of these objectives requires that monitoring of designated environmental parameters be conducted after completion of the two-year baseline data collection program until the termination of operations or until the AOSS determines to his satisfaction that environmental conditions consistent with the requirements of applicable statutes and regulations have been established. The Lease stipulates that after two years of baseline data collection the Lessee shall not be required to conduct a monitoring program on the leased lands until a date six months prior to the commencement of development operations.

The Monitoring Programs will compare data obtained during the baseline period with information developed during construction and operations in order to identify meaningful trends and changes. These trends may be represented by changes in the numbers of small mammals per acre, grams dry weight of grasses per acre, numbers of deer wintering on-tract, or numbers and age structure of fishes present in Piceance Creek. The trends will be analyzed statistically. For example, the mean biomass of an important prey species during the construction phase may be compared to the mean biomass (with plus or minus standard deviations) for that same species under baseline conditions using standard statistical tests to determine whether changes in biomass have occurred. To predict herbaceous productivity, one technique may include relating peak productivity to the previous winter's precipitation in order to observe what significant correlation exists between productivity and precipitation. In this way, observed and measured trends over a period of time can be compared statistically to baseline conditions and any significant changes detected and reported to the AOSS.

It must be recognized that there may be considerable difficulty in determining the cause of an observed change from baseline conditions because of the many variables which can cause changes. Most biological systems fluctuate around some mean value in response to environmental pressures, and observed departures from baseline conditions may reflect this inherent fluctuation. While a two-year baseline provides a gross value for measuring conditons, normal yearly fluctuations may vary significantly from any specific two-year period. The Monitoring Programs for Tract C-b are designed to take them into account and allow statistical comparison of observed trends with baseline data. Inherent in this is the necessity of replicating the techniques used in the Baseline Programs.

The material in this section is organized by subject programs, consistent with the approved baseline data gathering programs. For a description of the individual Baseline Programs, see Volume II. Detailed information and data for each of the Baseline Programs can be found in the five Quarterly Data Reports and five Summary Reports filed with the AOSS. Discussion of individual monitoring programs commences with a reference to the baseline program described in Volume II, and notes any significant program changes which are expected to occur during the second year of data gathering. It should be emphasized that all of the proposed Monitoring Programs are subject to periodic review and modification with the approval of the AOSS. In accordance with the Stipulations, all monitoring results will be included in an annual progress report to the AOSS.

B. Soils Survey and Productivity Assessment

Baseline Programs include a soils survey and productivity assessment for all proposed areas of disturbance. Maps and tables have been prepared illustrating various soils and soil layers by type, depth, strike, dip, slope, solar exposure, vegetative cover and erodibility. Soil analyses have also included determination of chemical, physical, and structural engineering properties necessary for feasibility evaluations of various proposed construction sites. These studies are of a non-continuing nature and will not be duplicated during the second year of baseline data collection. A description of the first year's baseline program and results is found in Section XII. Substantial additional engineering data will be acquired in the process of preparing definitive engineering designs for the mine and surface facilities. This data will be included in reports to the AOSS.

In order to provide documentation of any long term environmental effects upon soils, land forms and vegetative patterns, the Lessee proposes to obtain aerial photos of the Tract and surrounding areas upon completion of plant construction and at five-year intervals thereafter, until operations have been terminated and disturbed areas have been reclaimed. These photos will be compared with aerial photos taken when the Lease was obtained and photos taken during the baseline period. All visible changes will be noted and significant changes will be reported to the AOSS.

C. Surface Water

Extensive baseline studies are being conducted on surface waters. A description of the baseline program and results are located in Section IX. A.

No significant change is expected to be made in the surface water baseline program during the second year. However, the sampling frequency for chemical analyses will be reduced, and some technical changes will be made in analytical procedures in order to produce more useful data. All changes will be subject to the approval of the AOSS. Table VI-1 represents the revised analytical schedule. The network of thirteen surface water gauging stations will continue to be operated as in the first year.

Figure VI-1 is a map of the Tract showing the location of the principal surface facilities which will be constructed after approval of the DDP, as well as the location of surface water monitoring stations which would be included in the Monitoring Programs. The Monitoring Programs will utilize the existing stations which are included in the Baseline Programs, with some stations deleted.

Sorghum Gulch, the site of the processed-shale pile and containment dam, will be monitored by stations upstream and downstream of the pile. Those stations are existing stations #09306033 and #09306036 respectively.

Cottonwood Gulch, which will drain storm runoff from surface facilities, ore storage piles, roads and other construction areas, will be monitored by station #09306039.

Both Sorghum and Cottonwood gulches are dry gulches containing only intermittent water resulting from snow and storm runoff. Contamination of these waters will be avoided or reduced by the policies included in the Oil and Hazardous Materials Spill Contingency Plan and the Erosion Control and Rehabilitation Plan (see Section V.L. and V.K., respectively), by the catchment dams in Sorghum Gulch, and by treatment facilities.

Neither West Fork Stewart Gulch nor Middle Fork Stewart Gulch will be affected by major construction and operation activities. They will be monitored by moving present station #09306022, which is located above West Fork Stewart Gulch, to a new location below West Fork Stewart Gulch. The new location will monitor all flows from forks of Stewart Gulch.

Table VI–1 SURFACE WATER ANALYTICAL PROGRAM SECOND YEAR BASELINE PROGRAM SCHEDULE

Baseline Data to be collected monthly from 13 surface water gauging stations.

1.	Bicarbonate	(mg/1)
2.	Calcium	(mg/1)
3.	Carbonate	(mg/1)
4.	Chloride	(mg/1)
5.	Dissolved solids	(mg/1)
6.	Fluoride	(mg/1)
7.	Iron	(μg/1)
8.	Kjeldahl Nitrogen	(mg/1)
9.	Magnesium	(mg/1)
10.	Manganese	(μg/1)
11.	Nitrate & Nitrite	(mg/1)
12.	Oil & Grease	(mg/1)
13.	Phosphate, Total PO_4	(mg/1)
14.	Phosphate, Dissolved PO_4	(mg/1)
15.	Potassium	(mg/1)
16.	Silica	(mg/1)
17.	Sodium	(mg/1)
18.	Specific conductivity	(μmhos)
19.	Sulfate	(mg/1)
20.	Turbidity	(JTU)

Data to be obtained quarterly at stations 09306007, 09306022, 09306058 and 09306061.

1. Complete element scan

2. Radioactivity
   a. Gross Alpha (pcl)
      Radium 226*
   b. Gross Beta
      Thorium 230**
      Uranium**

3. Dissolved Organic Carbon (DOC)
   If DOC >10 mg/1, then
   a. Nitrogen (base extraction)
   b. Sulfur (acid extraction)
   c. Phenols
   d. Polycyclic aromatics

4. COD

5. Pesticides

6. Cyanide

7. Sulfide

* Required if Gross Alpha>4 picocuries per liter (pcl)
** Required if Gross Beta>1000 picocuries per liter (pcl)

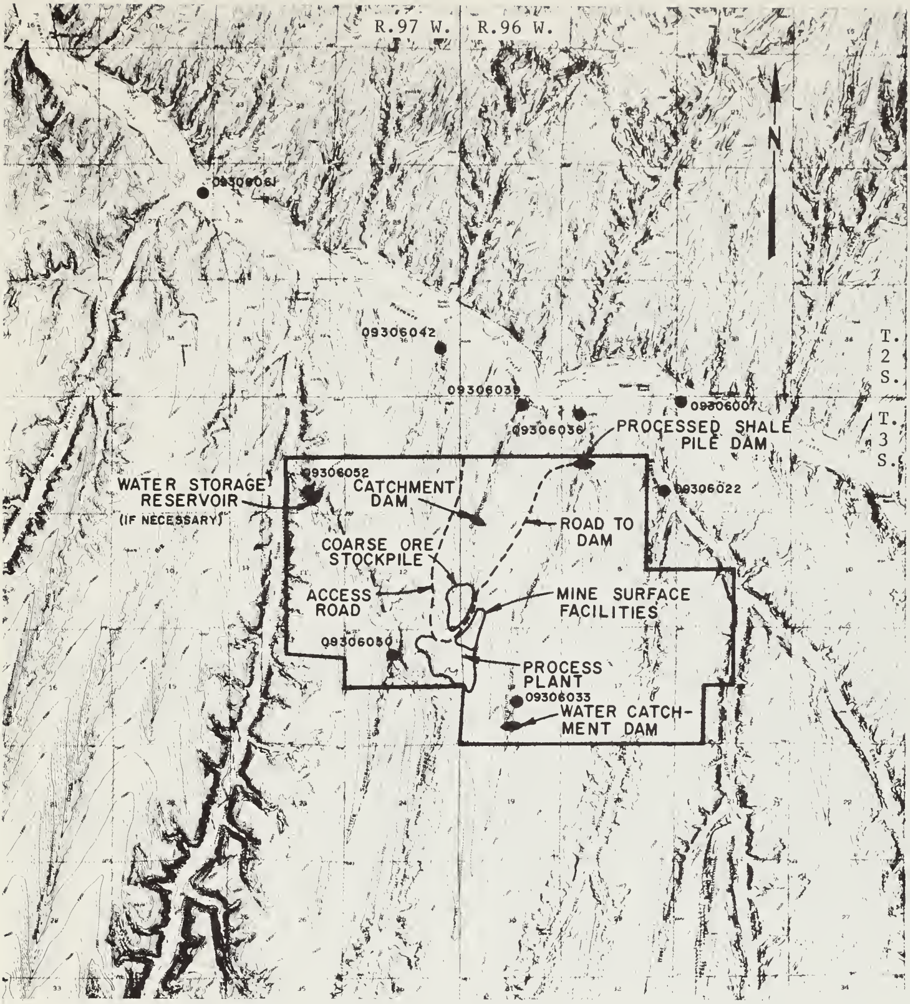


Figure VI — 1 SURFACE WATER MONITORING NETWORK

Piceance Creek will be monitored by existing stations #09306007 and #09306061 upstream and downstream of Tract C-b, respectively.

Existing station #09306052 at the mouth of Scandard Gulch will be used under all circumstances. Scandard Gulch is a potential location for a storage reservoir which may be used if mine dewatering flows require significant storage. Station #09306050 located near the southern tract boundary on Scandard Gulch will be left in place and used if major operational activity takes place in the gulch.

Each of the foregoing stations will be operated continuously during the development and construction stages of activity. After plant operations have been in effect for some time and monitoring conditions are stable, the use of monitoring stations on Scandard and Stewart Gulches may be discontinued or they may be sampled on a less frequent schedule. Sampling parameters and schedules for other stations will be reviewed and modified as appropriate after approval by the AOSS.

In summary, the following stations will be incorporated into the surface water monitoring program:

USGS No.	Station Location	Comment
09306007	Piceance Creek below Rio Blanco	operate during life of project
09306061	Piceance Creek at Hunter Creek	operate during life of project
09306033	Upper Sorghum Gulch	operate during life of project - relocate upstream if necessary
09306042	Unnamed Gulch west of Cottonwood Gulch	used to monitor road construction activities
09306036	Sorghum Gulch at mouth	operate during life of project
09306039	Cottonwood Gulch at mouth	operate during life of project
09306022	Stewart Gulch	consider removal or reduction if data is stable after period of commercial operations
09306052	Scandard Gulch at mouth	consider removal or reduction if data is stable after period of commercial operations
09306050	Scandard Gulch upstream	use only if dam is constructed in Scandard Gulch

During development and construction, the monitoring stations will be sampled on the same schedule and for the same parameters as they are in the second-year baseline program. As indicated above, both schedules and parameters will be reviewed for possible modification after the plant has been in stable operation for a period of time.

D. Subsurface Water

1. Second-year Baseline

The baseline data gathering programs on Tract C-b included intensive testing and monitoring of subsurface aquifers. A description of the first-year baseline program and its results is included in Section IX. B. The second-year baseline monitoring program for ground water studies remains for the most part unchanged. Some planned minor changes include the deletion of those elements which have never been found in any of the chemical analyses of water, and a reduction to once-per-year sampling of the bedrock aquifer wells. Alluvial wells will continue to be sampled at least twice a year. Any changes will be subject to AOSS approval.

2. Development Monitoring

After the second-year baseline data gathering program has been completed, a subsurface water monitoring program will be initiated in conjunction with mine development. The monitoring program is designed to monitor the following three major bedrock aquifer units:

- the Uinta aquifer, which includes the Uinta formation and the Parachute Creek section above the top of the Four Senators zone
- the Upper Parachute Creek aquifer, which encompasses the interval between the Four Senators zone and the top of the Mahogany zone
- the Lower Parachute Creek aquifer, which includes the interval from the base of the Mahogany zone to the top of the unleached zone

The monitoring program will use most of the present wells on the Tract. In general, modifications will be made in the shallow tubing strings so that the sections above and below the Four Senators zone can be monitored separately. Lower tubing strings will not be altered significantly. Any new wells will be evaluated for possible inclusion in the monitoring program.

In additon, as a part of the extended program, all present alluvial wells, except Well A-13, will continue to be monitored as in the past. Well A-13 will be plugged because it will be in the processed-shale disposal area. Following is a listing of the wells that will be recompleted as part of the development monitoring program, and the type of recompletion presently contemplated.

- wells SG-19, TG-71-2, TG-71-3, SG-1 and CB-2B will be recompleted so the Uinta aquifer can be monitored as a separate unit

- wells SG-18A, SG-20, SG-21, TG-2-1, TG-71-5 will be reworked so that the Uinta and Upper Parachute Creek aquifers are mutually isolated and can be monitored separately in the same hole

- well SG-1A will be recompleted so that the Upper Parachute Creek aquifer can be monitored as a separate unit

- well SG-19 will be twinned with a new well, and will be used to monitor the Upper and Lower Parachute Creek aquifers

No changes will be made in the other wells on the Tract during the initial part of the development monitoring program except for the plugging of TG-71-1 and TG-3-2 to prevent communication between the aquifers. Figure VI-2 shows the locations of existing wells which will be used in the initial phase of the mine development monitoring program.

Depending upon the results of Phase I shaft-sinking program, it may be necessary to recomplete those wells in the area that would be open to both the Uinta and Upper Parachute Creek aquifers. The purpose of this would be to prevent water from the Uinta aquifer from moving through the well bore down-hole and into the Upper Parachute Creek aquifer, and eventually into the mine. It also may be necessary to add Uinta formation and upper zone Parachute Creek monitoring wells as the mine-front advances in order to record changes in water levels and predict potential changes in water inflow into the mine. Some of these wells would most likely be drilled from within the mine.

Initially, monitoring samples will be taken on the same schedule used in the second-year baseline program. As more information and a better understanding of the nature of the aquifers is obtained, the program will be reevaluated and modified as appropriate. The frequency of sampling and the number of constituents monitored may be increased or decreased with the approval of the AOSS.

E. Meteorology and Air Quality

Extensive air quality and meteorological data gathering programs were conducted as part of the Baseline Programs. A description of the first year's programs and results are described in Section X. The program for meteorology and air quality for the second-year baseline studies will be similar to the first year's program, except for deletion of the upper air studies.

Monitoring programs for meteorology and air quality will involve ambient air quality, meteorology, visibility and emissions. Figure VI-3 shows Tract C-b with the approximate locations of planned plant and related facilities and the locations of the proposed air quality monitoring stations. The number of stations and their locations are approximate and may change as more data become available. Stack monitoring will be

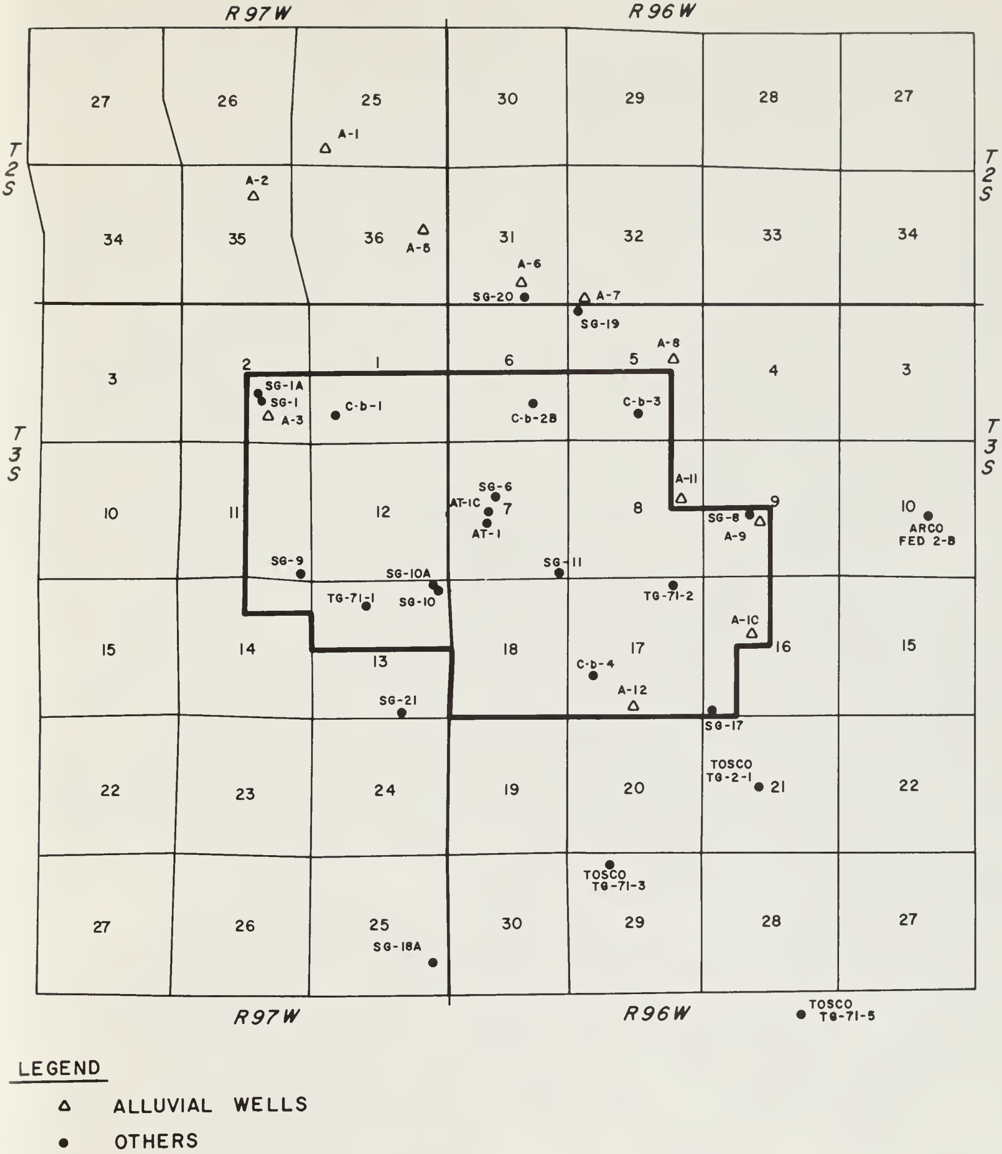


Figure VI – 2 GROUND WATER MONITORING WELLS accomplished according to federal and state regulations. Figure X-1 should be referred to in connection with the various air quality and meteorology monitoring programs described below.

1. Ambient Air Quality

The same air quality monitoring stations used during the baseline program will be used during the monitoring program and the same gaseous and particulate constituents monitored. Equipment will be the same, although some may be relocated. Prior to plant startup, varying levels of activity will occur in the vicinity of the Tract which will require different levels of monioring activity.

The continuing evolution of equipment and governmental regulations may require replacement or addition of new instrumentation. For example, it may be desirable to modify the stations to provide for data output at a central location. Changes in regulatory standards and analysis procedures may require changes in equipment, schedules, or data reduction. Such changes will be made when required or appropriate with the approval of the AOSS.

One year of baseline data has been obtained to evaluate suspended particulate size distributions and trace elements in suspended particulates. Levels of volatile trace metals (arsine, selenium, mercury) have also been determined. The Lessee expects to repeat these analyses during the six-month period prior to plant startup, during the first year of plant operations, and at periodic intervals thereafter. Sampling frequency will be increased if high levels of any toxic substances are found or suspected. During operations, spot checks will also be performed for ammonia.

2. Meteorology

The Baseline Programs include a detailed collection of meteorological data. A description and results of the first year's meteorology baseline program is located in Section X. No significant changes in the meteorology portion of the program are expected in the second-year baseline.

Meteorological measurements will be made at the 5 existing air quality stations. These stations will obtain measurements for wind speed and direction, temperature, relative humidity and precipitation. Some of these stations will be operated throughout the life of the project.

The existing 200-foot tower used in the baseline program and located at the proposed plant site (see Figure VI-3) may be left in place for possible use in tracer studies prior to plant construction, at which time it may be dismantled and moved to another site.

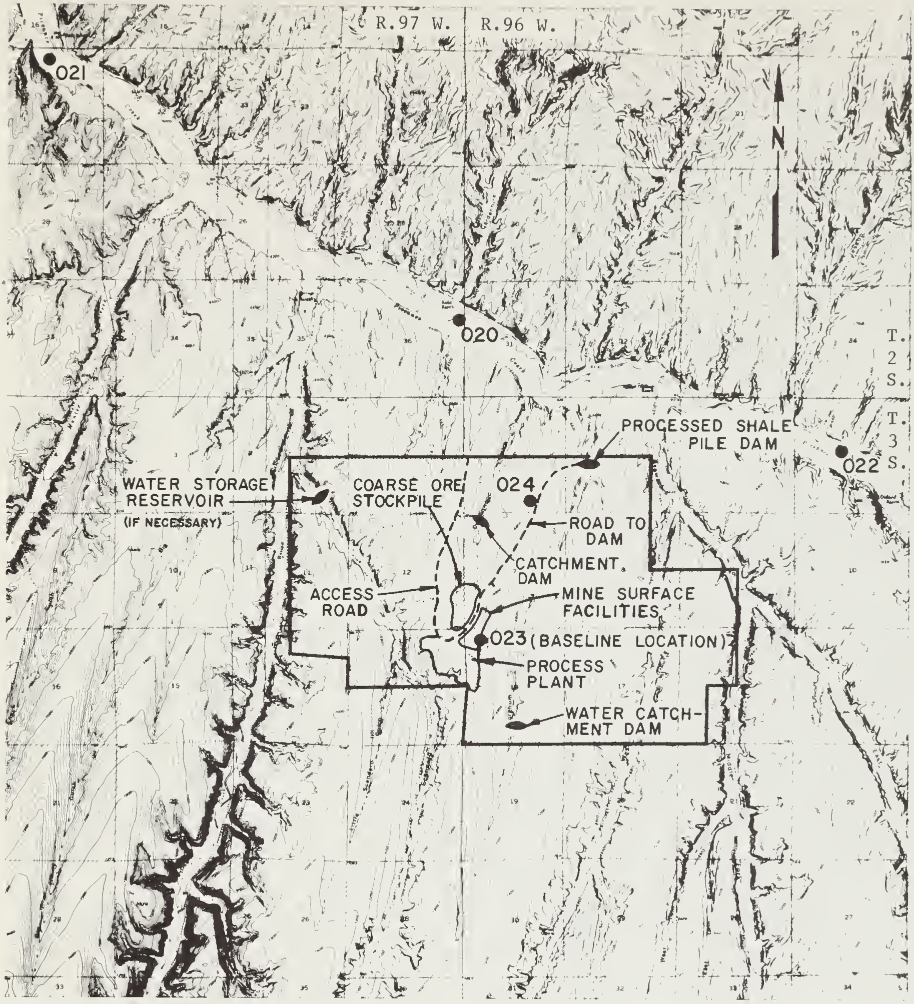


Figure VI — 3 AIR QUALITY MONITORING NETWORK

Normal replacement and upgrading of equipment will take place as improved technology is developed or changes in governmental regulations are made.

3. Visibility

The Lessee has begun a one-year visibility program. The selected area-wide technique utilizes photographic photometry. The visual range is measured every sixth day during the one-year study period. On these days, photographs are taken of four views covering an approximate 90° north-to-east section looking across the Roan Plateau from a site on the ridge west of Hunter Creek. Each view is photographed seven times during the day with black and white and color film. The contrast between the object image and the background sky is used to compute the visual range in miles. Following completion of the one-year program and evaluaon of the results, the Lessee will decide whether to continue using this method and, if so, whether to monitor continuously or on a periodic basis after plant startup.

4. Emissions

Monitoring of emissions involves measuring the rate and concentration of emissions from stacks and facilities to obtain representative measurements of emissions or process parameters. Performance test sampling is required to ensure compliance with specified emission standards under operating conditions. The results of such tests will be included in a written report and submitted to the appropriate regulating agencies. During plant operations, continuous stack sampling will be conducted in accordance with the requirements set forth in the appropriate federal and state air quality regulations for new stationary sources. Such monitoring requires specialized methodology which depends on the particular contaminant being sampled. The Lessee will apply that methodology in accordance with the requirements and procedures contained in the applicable performance specification set forth in the EPA's regulations for Standards for New Stationary Sources, 40 CFR Part 60, Appendix B. However, it is anticipated that emissions standards and monitoring methodology will change over the coming years. Thus final sampling schedules and metholology will depend upon the regulations in effect at the time of actual plant operation.

The Lessee will include in the design and construction of facilities the necessary sampling ports and access decks. Provision for isokinetic sampling of particulates will be included for typical stacks in the sections of retorting and crushing plants where the performance of pollution control systems would not be expected to vary among identical units.

As required by the performance standards for storage vessels for petroleum liquids, monitoring will be performed to determine and record temperature and true vapor pressure of stored petroleum liquids.

F. Biological

The environmental baseline data gathering program includes intensive studies of vegetation, mammals, aquatic life and birds. A description and results of the first-year baseline program is located in Section XI.

The second year of the baseline program will be a continuation of the first year's program. Minor changes will include modification of the number of samples and sampling periods. These changes have been approved by the AOSS.

The biological monitoring program is designed to measure changes in the ecosystem as defined by baseline data. The biological monitoring program will vary in degree of intensity as determined by the level of development, construction or operational activity on the Tract. During the mine development and construction phases of activity, monitoring schedules will be more intensive than during commercial operations.

The monitoring program should enable some distinction to be made between those biological changes attributable to oil shale development and those attributable to other causes. Methods used during the monitoring program will be precisely described and easily replicated.

1. General Monitoring Methods

The biological monitoring program will include monitoring of big game, major predators, medium-sized mammals, small mammals, avifauna, aquatic ecology and vegetation. In general, observation, pellet group counts and shrub utilization analyses on existing transects will be used to monitor big game numbers, movements, mortality and habitat utilization. Census methods to be used for coyotes include the continued use of scent-post surveys. These will also serve to document the presence of a number of other species besides coyotes. Observation is the method preferred for counting medium-sized mammals, while the monitoring of small-mammal population levels can be done by using existing grid locations to establish relative abundance estimates on a seasonal basis. Avifauna monitoring methods will include utilizing existing transects in selected habitats, studying songbirds during nesting season, examining ponds used by waterfowl, checking raptor nest occupancy for different species, and studying resident raptor species during winter to estimate relative abundance.

The general aquatic ecology programs monitoring methods include continuation of the present program for fish, benthos and periphyton. The frequency and number of sampling locations may be reduced. Water quality data will be obtained from the surface water monitoring program and correlated with sampling done for aquatic ecology.

Methods for vegetative monitoring include continuation of the present sampling program and productivity assessments on existing study plots, and the observation and measurement of revegetated areas. Color infrared aerial photography may be utilized on a periodic basis for comparison with previous data.

2. Specific Monitoring Methods

The following specific methods will be used in carrying out the monitoring, with possible modifications in the program occurring as a result of data collected in the first few years.

A summary of the biological monitoring program, including scope and frequency, is contained in Table VI-2. All biological programs will be reevaluated periodically.

a. Big Game

(1) Pellet-group Studies

Pellet-group counts will be continued at transects presently established in the Tract C-b area to determine deer-days and herd size in given areas, indicate relative changes in habitat utilization, monitor changes in deer distributions, and give an index of cattle and rabbit use. Three to five of the present sixteen transects (each 2450 feet long) may be destroyed during construction and operations. The destroyed transects will be replaced as required. In order to determine deer use and numbers in the off-tract area into which they may be forced to move due to development activities, five to seven transects on either side of the Tract will be established. Transects will be cleared of fecal pellets in the fall and one sampling period will be scheduled in the spring for this study.

(2) Browse Evaluation

Browse evaluations will be conducted in accordance with the schedule shown in Table VI-2. Browse evaluation will continue along presently established pellet group transects to provide an index to deer use and the condition of the winter range. Also, changes in browse conditions will be monitored at permanent vegetation study sites, utilizing the present deer-cattle exclosures, cattle exclosures, and adjacent open sites. Photographic documentation of browse conditions may be used.

(3) Deer Road Counts - Age-class Evaluation

Systematic weekly, or at least monthly, deer road counts will be performed from fall through spring over an established length of road. Monthly or bimonthly counts will include the number of fawns, does and bucks in the meadows along Piceance Creek. Counts made of deer seen within one-mile intervals, and notations of their use of meadows as compared to south-facing slopes, will give an indication of distribution changes. Notations of road kills will also be made.

(4) Deer Mortality

Selected sites will be checked for deer carcasses; the carcasses will be checked for age and sex, marked, and examined for the cause of death (disease, road kill or predation). One sampling period would likely be scheduled each spring.

Table VI–2 BIOLOGICAL MONITORING PROGRAM
Number of Sampling Periods/Year

	Year After Baseline Monitoring													
	1	2	3	4	5	6	7	8	9	10	11	12	13	Abandonment
Vegetation Studies:														
Productivity	A	A	A	A	A	A	A	A	A		A	A	A	A
Community Structure Studies	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Infrared Mapping					Q					Q				
Successional Studies	A	A	A	A	A	A	A	A	A	A	A	A	A	Q
Mammalian Studies:														
Big Game Studies –														
Pellet Group Counts	A	A	A	A	A	A	A	A	A	A	A	A	B	B to 20 yrs.
Browse Utilization	S	S	S	S	S	S	S	S	S	S	S	A	A	A to 20 yrs.
Live Trapping	S	S	S	A	A	A	A	A	A	A	A		B	B to 20 yrs.
Predator Studies	A	A	A	A	A	A	A	A	A	A	A		B	B to 20 yrs.
Track Studies Road Studies	A	A	A	A	A	A	A	A	A	A	A		B	B to 20 yrs.
Ornithology Studies:														
Breeding	A	A	A	A	A	A		B		B	B		Q	Q
Population Trends	A	A	A	A	A	A		B		B	B		Q	Q
Nest Occupancy	A	A	A	A	A	A		B		B	B		Q	Q
Wintering Residents	A	A	A	A	A	A		B		B	B		Q	Q
Aquatic Studies:														
Fisheries	I	I	I	I	I	I	I	I	I	I	S	S	S	S to 20 yrs.
Benthic Studies	I	I	I	I	I	I	I	I	I	I	S	S	S	S to 20 yrs.
Periphyton Studies	S	S	S	S	S	S	S	S	S	S	S	S	S	S to 20 yrs.
Water Quality	To be determined by water monitoring program													

I = Intensive Study (at least quarterly)
S = Semi-intensive (at least twice a year)
A = Annually (sampling in some sites each year)
B = Every two years
Q = Every five years

(5) Hunter Check Stations

Deer killed in the Tract area during hunting season will be counted and checked for disease and physical condition, if arrangements can be made with the State of Colorado.

b. Major Carnivores/Medium-sized Mammals

(1) Scent-post Surveys

Present scent-post surveys will be continued to document the presence of coyotes and other species. The U.S. Fish and Wildlife Service method will be used. This study will take place on several consecutive days during September.

(2) Observation

Scaled-down versions of the present observation studies will be used for species such as bobcats, beaver and foxes, big game such as elk, black bear and mountain lion, wild horses, and any rare or endangered species which occur. In the event that any rare or endangered species are encountered, specific monitoring studies will be initiated.

c. Small Mammals

(1) Live Trapping

The present live-trapping program for small mammals will continue at existing large grids and satellite areas, with the same information being gathered as during the baseline study. Relative abundance will be determined on a seasonal basis. Seasonal and annual population fluctuations of small mammals will be used as an aid in determining raptor and predator response and abundance. These studies may range from one to three sampling periods per year. The once-per-year sampling intensity would not permit a determination to be made of seasonal fluctuations. Sampling three times a year is expected to be done for the first few years to determine which sampling periods are most valuable. Winter sampling will be done only at satellite grids.

d. Birds

(1) Emlen Transects

The present program utilizing Emlen procedure to count songbirds during the nesting season will continue in the following locations: the area contiguous to that of maximum construction and operation activities; the zone where ground-level concentrations of stack emissions are projected to be greatest; and a control area. Similar habitats should be sampled in each of these locations. Initial periods of sampling will take place in mid-May, mid-June and mid-July, with subsequent evaluation of the results to determine whether these periods are necessary and are the optimum. Population trends of upland gamebirds using the Tract will be monitored in these studies. Nesting activities will be noted for both songbirds and upland game birds.

(2) Waterfowl Observation

The present program of systematic observation of the two ranch ponds now being studied, will continue in order to determine the extent of their utilization by wintering and nesting waterfowl. Observations will take place two or three times each winter and summer. Similar observations will take place at a more distant pond for control purposes.

(3) Raptor Nesting Study

Nest occupancy checks will be continued to determine trends in raptor utilization of the Tract and surrounding areas. This percentage of known nesting sites occupied by nesting pairs during each breeding season will be compared with baseline data. Studies will take place for various species during the breeding season: early-March (great-horned owls); late-April (red-tailed hawks, eagles); and early June (small owls, accipiters, kestrels, harriers). During the early-March observations, the relative abundance of raptors wintering in the area will be determined by observation.

e. Aquatic Ecology

(1) Fish

Shocking and marking of fish will continue, but the numbers of sampling stations will decrease to four or six. The frequency of sampling will be reduced to quarterly.

(2) Benthos

Present benthos collection programs will continue, but the number of sampling locations will decrease to four or six and the frequency of sampling will be reduced to quarterly.

(3) Periphyton

Present periphyton collection programs on artificial substrate will continue, but the number of sampling locations will be reduced to four or six. The sampling will be conducted quarterly.

(4) Water Quality

The present program of field investigation of water quality for biological purposes will continue. The analyses will be performed at the same time as biological collections are made. Additional water quality data will be obtained from the U. S. Geological Survey. Location and sampling times will be coordinated with the surface water monitoring program.

f. Vegetation

(1) Permanent Plots - Quantitative Sampling

The program of quantitative sampling of herbs, shrubs and trees will be continued to determine species presence, density (shrubs), cover, frequency, canopy cover (trees) and possible growth-rate differences in trees between a control site near the shale disposal pile and plant. Each site consists of three plots--one open, one fenced to exclude cattle and the third fenced to exclude deer and cattle. Sampling will be done on a rotational basis so that each plot is sampled at least once every three years.

(2) Permanent Plots - Productivity

The harvest method will be used for sampling of herbs and shrubs, once during peak season for several years after the completion of the baseline study and once per year thereafter.

(3) Permanent Plots - Phenology

Phenology studies may be continued minimally on herbs and shrubs every three to five years.

(4) Permanent Plots - Photographic Documentation

Changes in permanent plots will be documented by photography each year, and detailed photographs will be taken of sampling areas in the permanent plots.

(5) Tract Studies - Soil Fertility

Soil samples from each of the major soil types will be analyzed once every three to five years.

(6) Tract Studies - Aerial Photography

An aerial photography program for the entire study area will be continued at least once every three to five years. Using color infrared photography, vegetation changes stemming from construction disturbances can be evaluated, and judgments can be made as to the success of the revegetation/reclamation programs.

(7) Chemical Content of Plant Tissues

Plants will be collected, dried, milled, labeled and stored so that a future determination of the accumulation or biogeochemical cycling of substances produced during oil shale operations can be made. An analysis of plants for substances which at present do not now have obvious importance would thus be possible at a future date.

g. Soils

(1) Permanent Plots - Soil Bacteria

Nitrifying and denitrifying bacteria, azotobacter and actinomycetes will be sampled in each of the permanent plots over a period of three to five years. Some sampling will be done each year.

(2) Tract Studies - Soil Fertility

Soil samples from each of the major soil types will be analyzed once every three to five years.

h. Microenvironmental Studies

The four present microenvironmental stations will be maintained.

i. Contingency Monitoring

Contingency monitoring programs will be designed in the event that situations arise which cannot be studied using the methods contained in the above monitoring programs.

G. Noise

Noise monitoring is not required as a baseline data gathering program under the Lease for Tract C-b. However, as part of the baseline studies, the Lessee commenced noise studies in August 1975 to document existing levels of noise on Tract C-b and on the roads leading to the Tract. This study will continue for one year. The noise level measurement data will serve as a basis of comparison in the future.

A noise meter is being used to record noise levels at the locations shown in Figure VI-4. These locations may be changed or modified to enhance the noise-level measurement program.

The actual measurement procedure is described in detail in the Quarterly Data Reports. Measurements will be continued on a monthly basis for one year, at which time the data will be evaluated. Thereafter, the monitoring programs will be scheduled in accordance with the health and safety regulations. Colorado Highway Department statistics have been used with the "Nomograph for Approximate Prediction of Highway Noise Levels" to approximate the noise levels at the various locations shown in Figure VI-5. The maximum noise levels an observer standing 500 feet from a highway would hear for six minutes during the peak traffic hour in an average day in 1974 are shown in Table VI-3. The location numbers in Table VI-3 refer to traffic volume measurement locations shown in Figure VI-5. The noise level is expressed in units of decibels on the "A" weighting scale (dBA), which is a weighting technique used to approximate the response of the human ear to noise of various frequencies. L_{10} is the sound level that is exceeded 10 percent of the time for the period under consideration (i.e., in one hour, the sound level would exceed the value for six minutes).

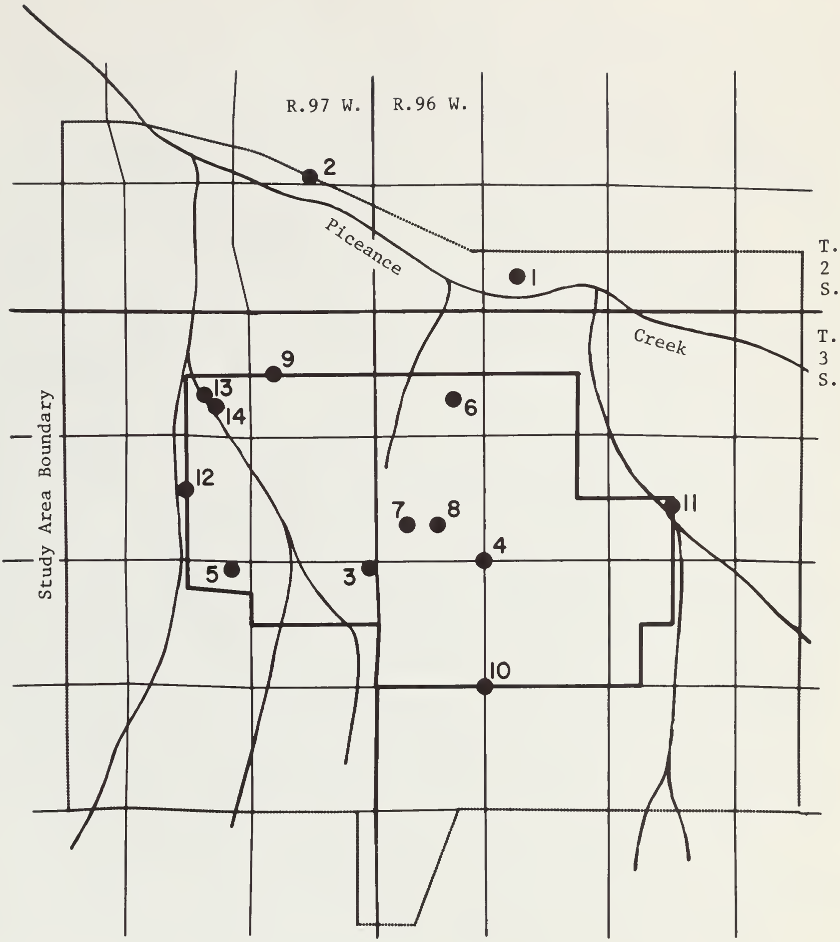


Figure VI — 4 TRACT C-b NOISE LEVEL MEASUREMENT NETWORKS

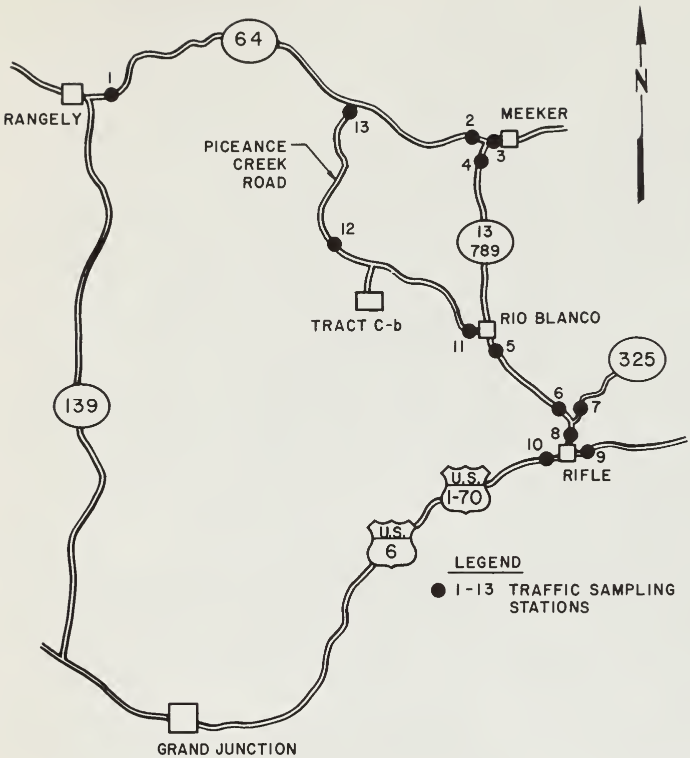


Figure VI – 5 TRAFFIC SAMPLING STATIONS – 1974

Table VI–3 APPROXIMATE TRAFFIC NOISE LEVELS[1] IN THE PICEANCE CREEK BASIN

(During peak hour of traffic, average 24 hour day, 1974)

Location Number	Location[2] Description	Noise Level[3] L_{10} dBA
1	S.H.[4] 64 east of junction S.H. 64 & S.H. 139	62
2	S.H. 64 west of junction S.H. 64 & S.H. 13/789	60
3	S.H. 64 east of junction S.H. 64 & S.H. 13/789	59
4	S.H. 13/789 south of junction S.H. 13/789 & S.H. 64	61
5	S.H. 13/789 at junction S.H. 13/789 & Piceance Creek Road	61
6	S.H. 13/789 north of junction S.H. 13/789 & S.H. 325	63
7	S.H. 325 east of junction S.H. 13/789 & S.H. 325	58
8	S.H. 13/789 south of junction S.H. 13/789 & S.H. 325	61
9	U.S.[5] 6 east of junction U.S. 6 and S.H. 13/789	66
10	U.S. 6 west of junction U.S. 6 and S.H. 13/789	66
11	Piceance Creek Road west of junction Piceance Creek Road & S.H. 13/789	53
12	Junction Piceance Creek Road and Local Road approximately 17.6 miles west of junction Piceance Creek Road & S.H. 13/789	53
13	Piceance Creek Road south of junction Piceance Creek Road and S.H. 64	53

[1] Noise levels predicted by utilizing 1974 Colorado State Highway Statistics, "Nomograph for Approximate Prediction of Highway Noise Levels," and data from Colorado State Highway Department Computer Program DFINCLS.

[2] Locations shown in Figure VI–5

[3] Noise level at location 500 feet from highway
L_{10} - the sound level that is exceeded 10 percent of the time for the time period under consideration (1 hour)
dBA - Noise level in decibels on "A" weighing scale, a weighing technique to approximate the response of the human ear to noise of various frequencies.

[4] S.H. - State Highway
[5] U.S. - United States (highway)